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A
NEW
PHILOSOPHY OF MATTER
SHOWING
THE IDENTITY OF ALL THE IMPONDERABLES
AND
THE INFLUENCE
which
ELECTRICITY EXERTS OVER MATTER
In Producing
ALL CHEMICAL CHANGES AND ALL MOTION.

BY GEORGE BREWSTER.

PUBLISHED BY CROCKER & BREWSTER, BOSTON
AND GEORGE BREWSTER, ADRIAN.

ADRIAN,

PRINTED FOR THE AUTHOR, BY

A. W. MADDOCKS.

1843.

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Entered, according to Act of Congress, in the year 1843.
BY GEORGE BREWSTER,
In the Clerk's Office of the District of Michigan

TO THE CITIZENS

OF

THE STATE OF MICHIGAN.

The Subscriber would beg leave very respectfully to inscribe, for considerations hereinafter to be stated, the following pages which are the combined result of several years investigation.

In some foreign countries, especially in England, where, by the peculiar constitution of the government, a monied aristocracy is created, and where wealth gives its possessor the means to acquire high intellectual attainments, it often happens that authors, who have not the funds and cannot risque the necessary waste of time which are required to spread their views upon any particular and important subject, lucidly and intelligibly before the world, are liberally aided, both by money and influence, in their enterprizes by some generous and noble minded individual of that aristocracy. Without such patronage they could never have been known as authors. Without it

"Full many a gem of purest ray serene,"

which has astonished and delighted and dazzled the world, would forever have lain embedded in the bosom of its native rock, and never have sparkled out in the day light.

Such authors, so situated, have, therefore, as a mark of respect and gratitude, and as was very appropriate, dedicated the results of their intellectual labor to such benefactors.

These, however, are not the considerations that have prompted a respectful inscription of the following work to you, fellow citizens

Among you there is no monied aristocracy. To no titled possessor of millions can an author here look for aid. But to you I dedicate it for several other reasons.

1st. Because Michigan is my chosen residence, my interests are identified in a measure with her prosperity, and I am frank to acknowledge a peculiar partiality for this young but brilliant star of the Union.

2d. Because this work, such as it be, is a *Western* work, and the design of its author is, that its pecuniary avails, if any, shall be applied to the promotion of Education within this peninsula.

3d. Because the favorable partiality of some of you, fellow citizens, induced the determination to publish, and to you, therefore, it, in a measure, owes its existence,

Faults it doubtless has—many faults—faults in style—faults in rhetorical construction and expression, which doubtless deserve and will, without mercy, undergo a caustic dissection and exposure by critics, but still the author thinks he may say, without vanity or egotism, that he believes it contains enough that is *new*, in theory and in fact, to justify its publication, else, he would never have permitted it to have become the property of the public.

With these brief reasons, fellow citizens of Michigan, for taking the liberty, unasked and without permission, to dedicate to you this humble, but sincere attempt to premote knowledge within the borders of this beautiful peninsula, I subscribe myself

Your very devoted
and humble servant,
GEO. BREWSTER.

ADRIAN, MARCH, 1843.

LECTURE I.

INTRODUCTORY TO A SERIES OF LECTURES

ON

THE IMPONDERABLE AGENTS.

THE present age is peculiarly and emphatically distinguished.—An important prophecy is in the very process of fulfillment. Many are "running to and fro" and knowledge is more rapidly increasing than at any former period of the world. Acceleration marks the progress of every thing. Instead of traveling, as formerly, at the snail like pace of three or five miles per hour, we now dart away upon the wings of steam, at a rate varying from *fifteen* to *forty* miles per hour. And the progress of man in science keeps pace with his progress in locomotion. This is quite as much owing to the fact that "many run to and fro," as to any other fact whatever. Individual acquisition in science is not so much hoarded as formerly. It is rather appropriated as common stock—rather scattered *broad cast* over the land.

There is another fact, which greatly accelerates the increase of knowledge. Scholars, at the present day, while following the direction of their inclination, and obeying the promptings of genius, confine their attention, more than formerly, to the thorough investigation of isolated branches of science, after having glanced, as in their collegiate course, at the whole routine of *general* knowledge.—One concentrates every energy of his intellect to the minute examination of *one* subject, another to *another*, another to *another*, and so on. Each investigates that branch, for which his mental habits and bias most peculiarly fit him. By such concentration, truths and facts in science are discovered, which would never have been discovered, by roving from branch to branch, and aiming to become what is called *a universal genius*. Thus has light been poured with intense radiance upon what was dark, and errors in both theory and practice have been corrected.

But even such an individual concentration of mind would not greatly accelerate the increase of knowledge were not the results of such concentration communicated. This is done through the medium of oral instruction as well as printed, for this is emphatically the age of lectures. Thus the labor of acquiring and diffusing knowledge is divided among a large number, and, by such a division, a vast multitude of important scientific facts are brought forth to light, which had laid dormant and undiscovered for ages, and might still have remained dormant and undiscovered for ages more withont the intervention of such agency.

The prevailing disposition of society is, also, auspicious. There is an insatiable thirst for knowledge and novelty, and any one, who can administer a palatable beverage to quench that thirst, is favorably received, and enjoys generally such a share of patronage, as to reward and stimulate his exertions.

Confident that this mental concentration to the investigation of isolated branches most effectually promotes the increase of knowledge, and that such an auspicious disposition prevails throngh intelligent society, I am induced to offer to the public a course of lectures upon a particular subject which I have investigated, with the assured conviction, however, that an author who publishes a book, or a lecturer who discourses upon a scientific or any other subject, should have *four prominent objects* in view

1st. SOMETHING NEW.
2d. SOMETHING IMPORTANT.
3d. SOMETHING TRUE.
4th. SOMETHING INTELLIGIBLE.

The reasonableness and propriety of each of those objects will be apparent upon a moments consideration.

1st. It should be one prominent aim of a writer or lecturer to produce *something new*, either by the discovery of latent facts, or the correction of untruths and false theories in science, or the systematic classification of facts long known, but long scattered in chaotic and useless confusion. For, to lecture or write upon any subject, without advancing new thoughts, or suggesting something which has not already been suggested by authors or by lecturers, seems to be "treading in the footsteps of our illustrious predecessors" to no very material advantage to the world. This, I am aware, is often done. A very considerable number of books, which, year after year, emanate from the press, and, no small share of the lectures delivered upon the sciences, are nothing more nor less than the repetition of old ideas in a new garb to prevent the petty plagiarism from being too barefaced, and that garb too oftentimes made less elegant and less attractive than the original. Something higher than this should be the aim of a lecturer. No bold, independent and vigorous thinker—none but a mere intellectual parrot, would stoop to such servile imitation of others, when before him lies, spread out in endless perspective, a vast, unexplored, immeasurable wilderness of knowledge, which would give scope for ages upon ages, yea for eternity itself, to the untamed energies of the most powerful intellect that men or angels ever saw.

But it must be acknowledged, that the fortune of him, who has thus forsaken the beaten path of generations, and has aimed at *originality*, has not often been an enviable one. Such an one has frequently ascertained, by bitter experience, how hard it was to "climb the steep, where fames proud temple shines afar:" He has often found that the untrodden course, which he has marked out for himself, has been any thing but a flowery path. Briars and thorns have grown thickly there. In it he has encountered the chilling blasts of poverty—the discouraging dissuasions of friends—oftentimes a concentrated and malicious chorus of serpent hisses from enemies, and has been pointed at with the finger of scorn, as a poor, crazy enthusiast, or a visionary builder of air castles. This conclusion will be irresistibly forced upon the mind of any one, who carefully consults the records of the past. When the celebrated William Wirt remarked, with regard to the perils of innovation, "*Woe betide the hand that plucks the wizzard beard of hoary error,*"—he was doubtless looking at the history of by gone time. Men used to regard the slightest encroachment upon established laws in *politics, religion* and *science*, how glaringly erroneous soever those laws might have been, as reckless and wicked fool hardiness. Facts in abundance prove this. A Columbus, a Newton and a Fulton might promulgate new theories of the utmost importance and sustain and defend them with argument piled upon argument mountain high—with argument upon argument, too, the most rational, conclusive and convincing, and they would invariably fail for a long time to convince. Prejudice, like an ancient mail coat of steel, enclosed the mind, and warded off the shafts of conviction. Many men and even men reputed to be scientific, would obstinately persist in scepticism, until actually *forced* to believe, by the *common sense* and the *common* opinion of the world around them—until the truth of rejected theories would blaze upon that scepticism with such overpowering intensity as to consume it, and make those, who harbored it, either ashamed of their extreme dullness of apprehension, or else of their dogged obstinacy.

The days of such prejudice and scepticism are, however, evidently passing away. It is true that men are cautious how they give a ready credence to novelties in theory or in practice, but, as a general thing, perhaps not too cautious. A certain watchfulness is doubtless necessary for the safeguard of the bulwarks of truth from sacriligious and ruthless innovation. But further than this, incredulity at the present day scarcely goes. So rapid, so surprizing and so successful have been and are still the improvements and discoveries of the age, that puzzled scepticism stands confounded and amazed, not knowing what to *say* or scarcely what to *think*. A very great change has come over the opinions and feelings of the world. Theories in science may now be promulgated, which discredit all preconceived sentiments upon the subject at issuse, and explode them, and still they will receive a candid and respectful hearing from an intelligent community—and if they happen to be supported by even the *plausibility* of argument, that thinking community will not reject, even if it do not embrace them. There will only be a suspension of judgment for *more light*. *This is wisdom.*—By such a course of policy, truth in science is sure to triumph and error to be overthrown and discredited, however subtlely interwoven with the maxims and policies of society and however supported by the authority of great names.

2d. It should be another prominent object of an author or lecturer to suggest *something important*. For, it should ever be kept in recollection, that "all is not gold that shines," and that, although "variety is the spice of life," yet, that what is *new* is not always *important* or *valuable* Ideas may have originality, and yet, at the same time, they may be either as simple as the babbling and nonsense of mere idiocy, or as unreal as the wildest and most incoherent ravings of stark madness—the likeness of nothing in the heaven above, or in the earth beneath, or within the whole wide regions of sober thought. Matter then, worthy of the attention of intelligent socienty must not only be *novel* but *important*.

3d. Another prominent object of an author or lecturer should be to promulgate *something true*. For ideas may be both *novel* and *important*, and yet, if they are incorrect—if they lack the very essential support of incontrovertible fact, they are unworthy of credence.—Without this, a theory may be both beautiful and grand, but must be as evanescent as it is beautitful, and as substantial as it is grand.

The example of Sir Isaac Newton is well worthy of the attention of scholars and authors. His discriminating intellect promptly and invariably rejected every theory and every proposition, however plausible, which had not the firm and imperishable basis of fact and conclusive demonstration. He jumped at no conclusion, but came to it step by step, through the path of clear patient and logical deduction. Away from his presence, he sternly rebuked every thing like surmise and conjecture, and gave no audience for a moment to any thing, which bore not the characteristic features of scientific truth. In this respect, imitation of him would not be reprehensible, It would rather be a mark of wisdom.

But 4th, to cap the climax, an author or lecturer should aim to promulgate *something intelligible*. This is quite as indispensable as any thing else. For thoughts may be *novel*, and *important*, and have enstamped upon them the characteristics of immutable truth, and yet, if they be not expressed so as to be *intelligible*, they might just as well not be expressed at all. The professed object of all language either oral or written is to convey ideas to the minds of those to whom it is adressed. But language, which is not understood, accomplishes not the object for which it was invented, or, if it be understood by only *one* tenth, then *nine* tenths are excluded from its benefits, just as much as if they were required to decypher the meaning of the obsolete Egyptian hyeroglyphics.

Now if an author or a lecturer have ideas to communicate, which seem to be sufficiently *novel*, *important* and *true* to warrant their promulgation, what should he do? Should he adapt his remarks exclusively to the taste and the comprehension of the few, who can emphatically be called the *literati?* Should he discourse learnedly in that technical phraseology, which, either from an imagined convenience, or else from the impulses of pedantic vanity, has been invented for the sciences, and which is as little understood by the mass of readers, as if those sciences were clothed in the dialect of one ot the dead languages? Should he be ambitious to throw an air of mysterious profundity, and scientific dignity around his remarks, or should he be mainly solicitous to be understood by all, and to adapt his language to the capacities of all of moderate attainments, either by avoiding *altogether* the use of blind and fresh coined technical terms, or else, by fully explaining those, which the imperious dictate of custom has made necessary and indispensable? There can be but one opinion upon this subject. The universal sentiment would doubtless be in favor of plainness. Aim to be understood instead of displaying ostentation would be the dictate of common sense. This can be done without sacrificing a proper dignity of expression or condescending either to a vulgar coarseness and rudeness of language, or a low and childish puerility of remark. It can be done too, without offending the taste even of the most fastidious among the scientific, or forfeiting the approbation of those, who combine a commendable public spirit with extensive acquirements, and who wish to see knowledge widely disseminated among the mass.

These four prominent objects, which have been thus considered separately, and which should be those of every author or lecturer, will be the landmarks by which I purpose to be guided in a proposed series of lectures upon the imponderable agents of Chemistry. It is my purpose that they shall contain, *novelty, importance. truth* and be made if possible, *intelligible*.

Floating through books and periodicals, various indefinite surmises or conjectures, respecting the subjects which I purpose to discuss, are to be found scattered here and there, but all confused. Nothing is systematized or affirmed with positive confidence and certainty, or supported with a proper array of facts and arguments, except in a single instance, in that almost unknown, but yet invaluable scientific Jewel—Dr. Metcalf's "New Theory of Terestrial Magnetism," published in 1833, in which he assumes and *proves*, by logical demonstrations, which cannot be successfully controverted, that *Caloric* is *Electricity*. After having written and lectured uopn this subject in Baltimore and other places in 1838, I was favored by a friend with the perusal of this work, and was agreeably surprized to find a perfect co-incidence between our views, so far as *Caloric* is concerned. By subsequent investigations I have come to the conclusion that, not only *caloric*, but that all the other imponderables are one and ı same agent.—That Electricity, Galvanism, Magnetism, Light, Ca ric, Gravitation, the Attraction of Cohesion, Capillary Attraction s Chemical Attraction are only different modifications of the same sential principle.

If this be true, as I hope, by facts and arguments to prove, tl there is an entirely new and unexplored field opened before the dent in Chemistry and natural Philosophy. By it, many things v be exploded as false, which have heretofore been taught in the schc as scientific truths, and many things will be systematized and sim fied, which have been complicated, confused and unintelligible. seems to lead directly to the adoption of this one broad and com hensive proposition—the basis or substratum of all knowledge.

There are, of the productions of creative power, three distinct essen or essential principles in the universe, and BUT *three, and every thing c ted and finite, of which we either have or can have any conception, wl er it be animate or inanimate—physical animal or intellectual, can h ferred to one or the other of these three essential principles, as to its na legitimate, proper basis or substratum.*

This proposition, it will be seen, embraces within its comprel sive scope the whole illimitable domain of science, both visible invisible. Sceptics in the republic of letters, or old fashioned b worms, who regard the slightest encroachment upon what they have read, as sacrilege, will doubtless call this proposition swee and chimerical. But sweeping and chimerical, as it may, howe seem to them or to others, it is believed, nevertheless, to be cap of satisfactory and even perfectly conclusive and logical demon tion, as will be shown hereafter.

The names of those three fundamental principles we will give in their natural order, together with a concise definitio their properties

The first we shall call *Ponderable Matter*, it being the same [illegible] epithet which is used in standard works. By this ter [illegible] those substances of every name and form, whicl tangible—which can be noticed or appreciated by most of the senses by which we acquire ideas of external objects—which are measurable, and which have magnitude and weight.

The properties or qualities of this first essential principle of the created universe we consider to be perfect inertness and inherent dormancy, meaning by those terms, that a substance under their influence has no activity or disposition to activity in itself—that it has therefore no power of changing itself, or of communicating motion to itself, either by component parts, or in the aggregate or whole—that it would, therefore, remain forever changeless, as when left at creation, and forever unvaried by modification, a cold, motionless mass of inertia or sluggishness, unless operated upon by foreign agencies, sufficiently powerful to overcome that inherent disposition to remain forever sluggish and unmoved.

The second essential principle embraced in our proposition we shall call *Imponderable Matter*, it being, also, the same technical epithet by which it is designated in the text books. By this term I include Electricity, Galvanism, Magnetism, Light, Heat or Caloric, Gravitation, the Attraction of Cohesion, Capillary Attraction and Chemical Attraction. These are all, in their nature, alike intangible. That is they cannot be handled so as to be examined like ponderable substances of the first class. They are inappreciable by most of the senses, immeasurable and have no perceptible magnitude or weight.

This *imponderable principle* is entirely distinct and different from ponderable matter, not derivable from it, but perfectly independent of it, and yet having such a natural affinity for it, by the inscrutable attraction of opposites, which seems to be an immutable law of nature, as to pervade it completely. Not a single particle of ponderable matter is there in creation—not an atom borne on the atmosphere—not a single mote floating in the sunbeam, but what is attended by its appropriate share of the imponderable principle, when all the elements are in equilibrium.

This wonderful and mysterious agent is extremely subtel—to subtle that it is invisible and imperceptible, except when condensed into the electric spark, or accumulated by the galvanic battery, or poured down upon us in the light of day, or gathered into focal intensity by the lens or burning glass, or exploded in the thunderbolt of the clouds, or collected together into that capacious reservoir of electric fire—*the Sun*. Elasticity unbounded is one of its characteristics and its activity is inherent and more restless than the ocean wave, it being always in motion, for, if the ballance of the elements be disturbed at all, and there be, any where in creation, a partial vacuum, or an abstraction of the subtle fluid, so far as to make that spot *minus* with regard to surrounding regions, it rushes in with irresistible velocity, and restores that disturbed ballance. Rapidity inconceivable characterises its movements. If impeded in the slightdegree in its everlasting career and accumulated and restrained by appropriate exciting causes, it exhibits a fearful energy—an energy perfectly overwhelming. and bursts its bands with infinitely greater ease than did the unshorn Sampson.

It is that agent, independent of Ponderable matter, at which we have already hinted, which pervades it omnipresently, according to certain definite laws, which will hereafter be explained, having a natural affinity for it, and possessing inherent power sufficient to overcome its inertia or sluggishness, to work all the chemical changes and produce all the motions in it, whether on the scale of atoms or of worlds or of constellations of worlds. It, in fact, seems to be the very Representative of Deity himself, expressly appointed and commissioned to produce the multiform and almost countless transformations of matter—all the chemical changes of decomposition and recomposition, which are constantly progressing around us and throughout nature, and, by its inherent energy, and the activity which it imparts, to keep up the motions of the universe of material systems, and to invigorate both the animal and vegetable life, in its myriad forms, with which those systems are furnished.

Some materialist may here draw the confident conclusion from what I have asserted, that imponderable matter is *mind*, and, that it is the *only Deity in the universe*. No such conclusion, however, results necessarily from the premises. Instead of favoring the doctrine of materialism in the slightest degree, I pledge myself to be prepared to show in its proper place in the series of lectures, that, from *this source*, alone, can be drawn the most powerful and convincing arguments which can possibly be drawn from nature to overthrow that doctrine. I am not one of those, who tremble to acknowledge an undeniable fact, lest that fact should seem, forsooth, to militate against my creed. The God of nature never would have created an agent, or have established a law, which, when *discovered*, and fully *understood*, would militate against his divinity, or undeify himself in the estimation of a *sound philosopher*. We must never deny the evidence of our senses, and discredit incontrovertible facts, lest, peradventure our *belief* should be overthrown by them, but should endeavor, by ingenuous and candid investigation, to ascertain *how they can be reconciled with our belief*.

We now come, naturally, to the *third* essential principle of the created universe, which we denominate *mind*. Pure etheriality seems to be its constituent property, which term, we think, will correctly define its nature, if, in the acknowledged vagueness, looseness and imperfection of language, all shall attach to it an appropriate signification. The intellect is no more a substance or the emanations of a substance, than thought or a train of thought is substance. As the emanations and exhalations, or the minute particles flying off from matter are matter *also*, so mind is, and, of necessity, *must* be, in the inherent fitness of things, of the same nature of its exhalations, which we know are *thought, intelligence, moral feeling and volition*, properties which may be truly said to be *something* or *realities*, though there be no *materiality* about them. Who, for instance, would affirm that an *idea* is matter? Has it length, breadth and thickness, either perceptible or imperceptible, as have all the particles of matter, either ponderable or imponderable, how minute soever they may be? To attempt seriously to disprove such a proposition would be too much like battling, with Quixotic valiancy, the unsubstantial shadows, which chase each other over the landscape. Such an attempt would sufficiently establish a man's claim to the diploma of a confirmed Bedlamite, and would entitle him, beyond all controversy, to a straight jacket, and an introduction to the benevolenthospitalities of a madhouse. Such a proposition is too preposterously absurd for a single moments belief. The influence which the intellect, or its controling power, the will, exerts over the other two fundamental principles of creation entirely precludes such a belief. For, as the imponderable principle controls the ponderable, so *mind* controls both the *one* and the *other*.

The intellect, or will of the carpenter, for instance, controls the muscles of his physical frame, through the action of the nervous fluid or animal electricity upon those muscles, and, by the strength and motions of his physical frame, so controlled, the edifice is constructed, and the grand, the beautiful and the symmetrical in architecture are made to adorn the dome, the temple and the various other fabrications of the mechanic arts.

The imponderable principle is, also, subject directly to the volition of intellect, although it has no guiding will of its own.

A Franklin, for instance, could extract the subtle fires from the storm-cloud, as it passed over head, with his electrical kite, and conduct the red and crashing bolt, harmless to the earth by his lightning rod.

Galvani and his successors could extract the same fiery fluid from a certain association of zinc, copper and the acids, in a stream strong enough to burn iron like tinder.

So we have seen that there are *three* created principles in the universe, each entirely diverse from the others, the first being under the control of the second, and both the first and second under the control of the third, as will be conclusively demonstrated, in that part of the following lectures, in which the Philosophy of *Animal Magnetism* will be investigated.

There is, in the universe, still another Principle,—if it be right to call the same a principle—which I have not included in my classification, because it comes not within the list of created substances. Its attributes are Omniscience, Omnipresence, Omnipotence and Eternity, as they must, of necessity be, in the very inherent nature and fitness of things, if uncreated or self existent, for an uncreated agent could not possibly be otherwise than infinite.

This self-existent, eternal principle we call Deity. Beyond Him we hold that there can be nothing either created or uncreated, finite or infinite. He embraces and controls and pervades and governs every thing. As electricity governs inert matter, and created mind governs both, in a certain sense, so this fourth mysterious, incomprehensible, all pervading Essence gives immutable, irresistibie laws to the whole three in an *unlimited* sense, and does precisely what he *wills* throughout the whole *illimitable* vastness of both *duration* and *space*.

In proof of the positions, which I have, in a measure, assumed, without having defended them with illustration and argument in the present lecture, the following work will consist of *thirteen lectures more*, in which it will be my object to investigate minutely the properties, laws and peculiar agencies of the three essential principles of creation, together with an occasional allusion to the uncreated Fourth, or the Supreme Architect. And I design, also, as deffinitely as possible, to show the relationship, which exists between those three essential principles.

The first subject of investigation will be *common electricity*. I shall show *how* it was discovered, what are the immutable laws by which it is ever governed, and what are the manifold and powerful agencies or influences, which it exerts over matter, in the production of all chemical changes and all chemical analysis.

I shall then investigate, in their appropriate order, the other imponderables, viz: Galvanism, Magnetism, Light, Heat or Caloric, Gravitation, the Attraction of Cohesion, Capillary Attraction, Chemical Attraction and Animal Magnetism, and show that they are governed by precisely the same laws as common Electricity, that they exert the self same influences over inert matter, and that they are, therefore, the same individual agent, though known by a variety of names, and exhibited under a variety of modifications.

During the course of this investigation, I shall endeavor to show, that the Sun is the grand reservoir of electricity—the great galvanic battery of the solar system—that its influence over the planets is *electric*—that their motions, both diurnal and annual are produced by that influence, in accordance with those electrical laws of attraction and repulsion, which can be tested in the laboratory upon little pith balls—that the Attraction of Gravitation, as well as that of Cohesion, is caused by the light and Caloric of the Sun, in their operation upon the material of the earth, in constituting it a magnet—that terrestrial Magnetism and the north and south polarity of the earth, which attract and guide the needle of the mariners compass, are produced by the same cause; that the reason why the needle points to the north and south, rather than to the east and west, is because electricity, it is now well known, influences and guides it, and because those streams of Caloric or solar heat, which, in obedience to an immutable law of nature, run continually from the equatorial regions to the point of greatest cold in the polar regions is *that same electricity*—that that point of maximum cold is proven, by the observations of navigators, in their voyages of exploration in the high latitudes of the Arctic and Antarctic seas, to be the magnetic pole of the earth both north and south, which varies from the geographic pole, in some seasons, fifteen degrees or more—that the Aurora Borealis and Aurora Australis, or Northern and Southern Lights, stream up from these points of greatest cold, or the magnetic poles of the earth, and are, therefore, the electricity or Caloric, that runs continually from the equator to those magnetic poles, and there passes outward and upward, into the rarer regions of the atmosphere in its circuit, and forms precisely the same lambent, nebulous, waving appearance, which electricity exhibits, when passing through an exhausted glass tube, or any other exhausted medium.

I shall endeavor, also, to demonstrate, by conclnsive proof, that it is the vivifying principle of both animal and vegetable life, and, as far as possible, in a science as abstruse as this, to show *how* it operates—that it is the active efficient agent of both the decomposition and the recomposition of the organic structure of men and animals, which is continually going on—that its application in cases of disease, by those, who understand thoroughly its laws and chemical agencies, is of invaluable consequence, whether it be by machinery, or by animal magnetism, and that by its scientific and proper application, it can be made to cure Epilepsies, Apoplexies, Palsies, Rheumatism, Fever and Ague, and, indeed, almost every other disease that "flesh is heir to," except old age, and both *how* and *why*, in most cases, it can be done—that it can be done by known and tested chemical agencies, in strict accordance with immutable chemical law.

And, finally, I will endeavor to show what influence mind has over this subtle agent, in producing the motions of the human body, and wherein that influence is different from the choice or instinct, which controls the motions of brutes, by which I shall prove that Animal Magnetism, so far from being a "*miserable humbug*,' is a sublime science, which can be sustained by as many incontestible proofs as any science under heaven—proofs too, which, if any man would seriously doubt, he must first, doubt the evidence of his own senses, or his own personal identity.

I shall, also, show, that Animal Magnetism, so far from having a tendency, as some suppose, to bring the truths of our holy religion into disrepute and discredit, lends a most efficient and powerful aid to sustain them, and, rightly considered, must lead every candid mind to the conclusion, that we are, in truth, "*fearfully and wonderfully made.*"

In the discussion of those subjects, it will be perceived, by a perusal of the following pages, that I have, in many parts, adopted the argumentative style, based upon a few choice facts, selected from a mass, that might have been collocated and inserted, and that, in some places, the thread of argumentation, is drawn out somewhat attenuated.

This has been done *purposely*, from the fact that I was aware that many, and indeed almost all of the most important positions taken, were *novel*, and needed, of consequence, to be defended at every apparently assailable point, from the attacks of prejudice.

After having spread these views, however, before the public, in this manner, it is my intention, when the novelty of the theory shall have worn off, and critics shall have exhausted their quiver, and fired at it their last shaft, and it shall, perhaps, have gained here and there a solitary advocate, to prepare, out of the substance of the materials here furnished, a class book for schools, adapted to the present improved state of Chemistry and Philosophy.

For the instruction and particular benefit of those readers, who may not be perfectly familiar with the subject of Chemistry, and with the signification of those technical terms and phrases, which are somewhat uncommon, but whose use custom has made in a measure indispensable, I intend to collocate such uncommon words, terms and phrases, in a vocabulary at the close of the volume, and give a concise and minute definition of each. To that dictionary we would, therefore, refer the reader, for the meaning of all words, which are not in common use.

LECTURE II.

SUBJECT—COMMON ELECTRICITY.

THE subject of the present lecture is *common Electricity*. I distinguish it by the epithet of "*common*," not because there is any *essential* difference between it and Galvanism or its other modifications, but because the phenomena, which we shall investigate in the present lecture, are those, which have been the longest and the most universally known, and, with the manifestations of which, all are more or less familiar.

This subject we intend to examine critically and very minutely, for, upon it is based an important science, and, in order to understand that science thoroughly, we must thoroughly investigate its elementary principles. By the unerring test of experiment, we shall, upon a small scale, within the immediate purview of the senses, determine the laws and the agencies, by which it is ever governed. Having ascertained these, with satisfactory certainty, they will serve the valuable purpose of a chart, a compass and a pilot, as it were, upon the broad and interminable ocean of investigation, far from the sight of land. Yes, with these valuable auxiliaries, we can enter the vast laboratory of nature, and show how, upon a large scale, the planets are wheeled upon their axis, and impelled in their mystic dance around the Sun, by the self same force that attracts and repels pith balls. For no one will dispute the fact, that the aggregate or whole is governed by the very same laws and agencies, by which the individual parts and particles of that whole are governed. This proposition will be found to be unerringly true, apply it *where* you may, and as *extensively* as you may. The law, by which an atom gravitates, or several atoms cohere or cling together, is the law precisely by which worlds gravitate and cohere. The laws, by which a drop of water is held in a globulous state, are the same precisely, which hold the ocean together. There is no deception in nature. She is no coquette. She speaks the language of uniformity and consistency throughout her wide dominions, and you will never find her conduct, at one time, or in one respect, at variance with her conduct in another. Having ascertained a fact or law in physics, beyond the possibility of mistake or the shadow of a doubt, other facts and other laws, bearing a relation to the same thing, will, when discovered, uniformly and universally sustain the first fact or law. This admirable certainty and uniformity in the operations of nature enables astronomers to foretell eclipses for years before their occurrence with confidence, and to the definiteness of a single moment, to predict the transits of Venus, and give almost the precise data, even, for the flight and return of the eccentric comet.

Electricity was first detected or discovered in a substance called in English, amber, which substance in the original Greek was called *electron* from which the term *electricity* is derived. This word *electron* is also derived from *clectore*, another Greek word, which signifies, *the beaming Sun*, and, if it does not indicate that the ancients supposed the Sun to be the fountain of this subtle fluid, it, at least develops a remarkable accidental coincidence.

Thales, a celebrated Grecian of the city of Miletus in Ionia, who lived 600 years before the Christian era, and who was the contemporary of Pythagoras, is reputed to be the discoverer of this remarkable property of amber. He ascertained, probably by accident, that when rubbed, it acquired the power of attracting to itself certain light bodies in its immediate vicinity. For the want of amber, the student can illustrate the phenomenon with a stick of sealing wax.

Familiarity with facts should never be suffered to lesson their interest, nor should we overlook the simplest truths, for, a thorough knowledge of those simplest truths, ofter leads to the discovery of the grandest and most sublime, while he that despises the day of small things," will, probably, never live to see the day of large things. The most magnificent results often thus originate. The dim dawning of the morning precedes the blaze of the meridian. The diminutive acorn springs up and becomes an oak, monarch of the forest. The majestic Amazon first issues as a little rill on the eastern declivity of the Andes. A neglected spark kindles a conflagration and millions of wealth are lost in ashes. So with a thousand other facts. Their origin is simple but their results are grand.

As the sealing wax before being rubbed is passed over little bits of paper prepared for the purpose, they are perfectly quiescent. Both are in a state of natural equilibrium or ballance. Having excited it however, by friction, it immediately exhibits a singular power unknown to it before. In this little experiment, trifling and simple as it may appear, there are treasured up volumes of wonder and inscrutable mystery, enough to puzzle for ages, the clear sighted penetration of a Newton himself. What is it that first diffuses over those bits of paper, a tremulous quiver? then sets them upright as if alive, and then makes them leap up, as if either in affection or in anger, to the cause of their momentary animation. Echo only answers—"what is it?" The chemist is puzzled and silent, the books answer not, and no one can tell. The influence of the charmed sealing wax over those bits of paper is beyond the comprehension of the most gigantic intellect. All that can be known is that it is *Electricity*, and that its operations are guided by certain fixed and immutable laws.

No wonder Thales stood in astonishment, when he made the discovery. No wonder he thought the amber animated with a principle of vitality. The emotions of the mind, when a grand fundamental or elementary truth first breaks upon it, are unuterable, and cannot be apprehended by the dull phlegmatic, who always plods along in the beaten path of his grand fathers. Such emotions often find vent in exclamations, similar to those of Archimides in Greek, when he had discovered the solution of a difficult problem, upon which he had been long and intensely studying. In extacy he exclaimed—"*eureka—eureka*"—"*I have found it—I have found it.*"

Before proceeding, it may be proper to remark, that Thales was no ordinary man. "Like most of the ancient Grecian sages, he traveled into Egypt, lived in that country several years, contracted friendships with the priests, then the depositories of science, became deeply skilled in all their mysteries and learning, and, returning to his own country deeply stored with the knowledge of the East, he ranked as the first of the seven wise men of Greece, and became the founder of the Ionic school." Apuleius, an eloquent writer of the second century, thus speaks of him.

"Thales, the Milesian, was decidedly the most eminent of the seven famous sages; for he was the first inventor of geometry among the Greeks, the most judicious enquirer into the causes or nature of things, the most skillful observer of the stars; he made great discoveries by small geometrical lines, in the regulation of times and seasons, the theory of the winds, the course of the stars, the *wonderderful causes of thunder*, the oblique motions of the planets, the revolution of the Sun and the reason of the increase. decrease and eclipse of the Moon."

From the time of Thales to that of Theophrastus, a disciple of Aristotle, who lived between two and three centuries after him, no new discoveries were made in electricity, which is somewhat surprizing, since it is no local or occasional agent, but coeval with time, pervading all substances omnipresently, and being the palpable cause of some of the grandest scenes in nature.

In a work of Theophrastus, entitled in Greek, "*Peri Lithone,*" he ascribes the same property, which Thales discovered in *electron* to the lapis lyncurius, the substance now called Tourmaline. "It posesses," says he, "an attraetive power, like amber, and, as they say, attracts not only straws and leaves, but copper also and iron, if in smalll particles."

From the period of Theophrastus, no allusion is made by authors, for more than two thousand years, to any but the discoveries already noticed, and, therefore more than twenty three centuries elapsed from the observations of Thales, before any material addition was made to the stock of electrical knowledge. Since that, for the last two centuries, its accumulations have been vastly more rapid and increasingly important.

In 1600, William Gilbert, physician to King James I, in a Latin work, entitled "*De Magnete, magnetesque corporibus*," gives a description, towards its close, of a great variety of electrical experiments, entirely new.

A fresh impulse appears to have been given, during this century, to the study of electricity, by the discovery of the phenomena of magnetism, as it seemed in some respects to possess properties similar to the loadstone.

By his experiments, Dr. Gilbert added largely to the meagre list of electrical substances. He ascertained that Diamonds, Saphirs, Carbuncles, Iris, Opals, Amethysts, Beryl, Crystal, Bristol Stones, Sulphur, Mastick, Hard Wax, Hard Rosin, Arsenic, Sal-Gemma, Rock-Alum, common Glass, and Stibium, or Glass of Antimony, have the power, when excited, to attract light bodies, and that this influence is not only exerted over leaves and straw, but, indeed, over all matter, which is not extremely rare. He also ascertained that friction was necessary to produce electrical phenomena, that it was most potential when light and quick, and that electrics could be most strongly and permanently excited, when the air was dry and the wind north or east.

For the want of suitable apparatus, this philosopher encountered many obstacles, as did all the rest of the early investigators of the science. His experiments were principally made with long, thin pieces of metal, and other substances freely suspended on their centers, to the extremeties of which, he presented the electrics he had excited.

Thirty years after the publication of "*De magnete, magneticisque* corporibus," the celebrated Sir Kenelm Digby, in his "Treatise concerning the nature of bodies," expresses the following singular notions respecting the influences of electricity.

"Attraction," says he, "is made by an attenuated emanation or a continuous effluvium,which, after some distance, retracteth into itself, as is observable in drops of syrups, oils, &c., which, spun at length, retire to their dimensions. Now these effluviums, advancing from the body of the electric, in their return, do carry back the bodies, whereon they have laid hold, within the sphere or circle of their continuities; and these they do not only attract, but, with their viscous arms, hold fast a good while after, and, if any shall wonder why these effluviums, issuing forth, impel and protrude not the straw before they can bring it back, it is because the effluvium, passing out in a smaller thread and more enlengthened filament, stirreth not the bodies interposed, but returning into its original, falls into a closer substance and carrieth them back into itself."

Such fanciful hypotheses may be amusing, and exhibit an inventive ideality, but should never be indulged by a philosopher, in the form of positive assertions, unattended by positive proof, as in the quotation just made. They advance not true knowledge, but rather becloud and bedim it.

The learned Mr. Boyle, by his investigations towards the close of the seventeenth century, enlarged the catalogue of electrics somewhat, and ascertained, by his experiments, that the electrical properties of bodies are increased by wiping and warming them, before they are rubbed. Bodies of all kinds he supposed were attracted indiscriminately, and that this attraction took place in a vacuum as well as in the open air.

To this time philosophers had supposed that electricity possessed only an attractive power. For Dr. Gilbert, in his "*De magnete, magnetesque corporibus*," remarked that magnetism possesses both an attractive and a repulsive power, but that electricity possesses the latter but not the former. Boyle, however, approached so far towards the discovery of repulsion, that he remarked, that feathers and other light bodies would cling to his fingers, after they had been attracted by electrics.

Otto Guericke, who lived contemporary with Mr. Boyle, and who is famed for his invention of the air pump, made still further discoveries and improvements. He made use of a sulphur globe, whirled on an axis much in the same way with our present glass globes. By this apparatus he could accumulate a greater amouut of electricity than had hitherto been accumulated, and was, therefore, enabled to experiment with greater success and certainty than his predecessors. To him is due the honor of making the first full and satisfactory discovery of electric repulsion. "A body once attracted," says he, by an excited electric, is repelled by it, and not attracted again, until it has touched some other body. He kept a feather for a long time suspended in the air above his sulphur globe, and made also the remarkable discovery, that, when repelled by an excited body, it always keeps the same face towards that body, as the moon does towards the earth.

Both Mr. Boyle, and Otto Guericke discovered the electric light, simultaneously, the one, as he supposed, in the diamond, and the other in his excited globe.

Dr. Wall, about the same time, discovered it in a still more satisfactory manner, which I will give in his own words.

"I found," says he, "upon swiftly drawing a well polished piece of amber in the dark, through a piece of woolen cloth, and squeezing it pretty hard with my hand a prodigious number of little cracklings were heard, and every one of them produced a flash of light, but when the amber was drawn gently and slightly through the cloth, it produced only a light, but no crackling; but by holding ones finger at a little distance from the amber, a large crackling is produced, with a great flash of light succeeding it, And, what to me is very surprising, upon its eruption, it strikes the finger very sensibly, wheresoever applied, with a push or a puff like wind. This light and crackling seems, in some respects, to represent thunder and lightning.

Sir Isaac Newton next made the discovery of a fact, which has often been disputed, but which is very necessary in establishing the theory which I assume, that both electric attraction and repulsion will penetrate through glass.

Mr. Hawkesby next in chronological order, wrote, in 1709, a treatise on electricity, in which, he published a variety of new facts with regard to attraction and repulsion, and the nature of electric light, supposing it to be phosphoric. Others, who first observed it, at this period, adopted the same opinion.

About twenty years after, when the excitement produced among scholars, by Newton's wonderful discoveries in Natural Philosophy, had, in a measure, subsided, Mr. Grey turned his attention to the subject of electricity, and by him was discovered the *distinction*, which exists between electrics and non electrics, forming a new era in the history of the science. But as a detailed account of the interesting experiments, which he made and published in the Philosophical transactions for 1729, would be altogether to voluminous for the circumscribed limits of the present lecture, I shall simply allude to the fact, and pass on to the consideration of other important topics and experiments.

Thus far I have glanced rapidly, and, in as brief a manner as I well could, at the history of the rise and progress of this science, and less than this I could not well have done, consistent with a thorough examination of the subject. And what is the sum of our investigations thus far? It is this.

Amber and a great variety of other substances are capable of exhibiting electrical phenomena. Friction is, generally speaking, the cause of the exhibition of such phenomena. When they are made by friction to exhibit those appearances, they are said to be electrified or electrically excited. and the power of attraction, which they then exhibit over contiguous light bodies is denominated electrical attraction.

But this is not the only power manifested, or the only influence exerted, by this agent, over bodies or in conjunction with their own properties. There is a *repulsive* as well as an *attractive* force. This attraction and repulsion, depend, as will be seen, upon the different electrical states of different bodies.

For illustration, rub a glass tube. It becomes electrically excited. Hold it over little bits of paper. They are attracted towards it from some distance, and with considerable force. But you perceive that the moment they come in contact, they receive a portion of the electricity, which attracted them, and are immediately repelled.—Dropping, however, upon some other substance, they impart to that substance a portion of the electricity, which they received from the glass and are again attracted towards it, though with less force than before, because it is less excited than before, having, in the first contact lost a portion of its superabundant electricity. This alternate attraction and repulsion continues, though more and more feebly, until the excited substance has lost entirely its electric charge, and has returned to its natural state. It then exhibits no attractive powers whatever. Contiguous light bodies, however light and easily moved, remain perfectly unaffected and quiescent at its approach.

Another piece of apparatus, by which attraction and repulsion are still more forcibly and amusingly illustrated, is what is called the apparatus for the dancing figures, by which, pieces of paper, or images cut from paste board, or the pith of elder, are made to dance between two plates, by the action and reaction of positive and negative electricities.

How wonderful the agency here exhibited? Who does not look with astonishment upon the mock creative and life giving energy, which electricity displays. Had some chemist made an exhibition like this in the dark ages, without explanation, or even in the days of Salem witchcraft, it would have rung throughout the country, that he had made a league with the evil one, and he would, as a compensation for his wisdom and wit, have stood a pretty good chance to get a roasting for a wizzard. There is a case on record, directly in point. John Faust, an ingenious German, by the invention of types, was enabled, during the dark ages, not only to publish books much faster, but also much *cheaper* than before. This newly discovered art he kept secret for a time, and hence originated the nursery legend of *Dr. Faustus and the devil*, in which he is represented as calling to his aid unlawfully the spirit of darkness.

There are many substances—all the metals in particular—which do not seem to be capable of being electrically excited by friction. The reason, however, is obvious. They give a free passage over their surface to the electricity as it is excited, and it is instantly dissipated without being accumulated in any perceptible quantity.

These are denominated non-electrics, from the fact that they are not capable of being excited like glass and the resins. They are also called conductors, from the fact that they readily transmit the subtile agent without accumulation upon their surface. But it is *only* because they are good conductors that they happen to be non-electrics. Let them be insulated—that is, let them be placed upon some electric or non-conductor, such as glass or gum lac, and they immediately become electrics by friction, or by the communication of the positive charge from an electric machine, and exhibit the same phenomena as glass, sealing wax or any other excited electric. The reason then, why some substances are electrics and some non.electrics, is because some substances seem to have a greater power of affinity to retain what is collected upon their surface than others.

The body of a living person, for instance, is one of the best conductors of electricity, or non-electrics, and yet it can be made a most perfect electric by insulation.

Our observarions thus far, aided by our experiments, have been the means of ascertaining these three facts.

1st. *Bodies electrically excited attract bodies unexcited.*

2d. *Two bodies electrically excited, as when one excited body has imparted a portion of its electricity to an unexcited body mutually repel each other.* And

3d. *Two in their natural state have no perceptible influence upon each other, but are perfectly quiescent.*

It follows, then, as a matter of course, that these three facts lay the foundation for three distinct propositions.

1st. *Opposite electrical states attract.*

2d. *Similar electrical states repel.* And

3d. *When bodies are in their natural state, they are in a perfect equilibrium or a ballance, exerting neither an attractive nor a repulsive influence.*

The question here naturally suggests itself—What are those two opposite electrical states, spoken of in the first proposition? Are they two distinct electrical fluids, or only one? I here use the term fluids, not because I consider it an appropriate term, for I cannot conceive that the word fluidity, in its general acceptation, conveys a correct idea of the movement of electricity, but I use it simply in accomodation to the inappropriate phraseology of those standard works, from the theories of which I am obliged to dissent. Are the opposite electrical states, I say then, two distinct fluids, speaking in the language of the books, or only one? Eminent philosophers have been divided upon this point. While Du Fay, Symmer, Coulomb, Turner, Thompson and others believed that there are two, with opposite inherent natures, Dr. Franklin, Epinus, and Cavendish, with some modification of each others views, maintained as positively that there is but one.

I will first state briefly the peculiar views of these two classes of celebrated opponents, examine very minutely their arguments, show how far I agree with them, wherein I differ, and the reasons which compel me to differ. My object in thus minutely investigating these two theories and in attempting to ascertain the truth in the case, is to lay broadly and permanently, upon the immoveable and imperishable basis of fact and argument, the foundation of that system of philosophy, the superstructure of which will be built up in future lectures. An error or a doubt or an uncertainty *here*, will be of serious detriment throughout the whole series, for my theory must stand or fall by the stability or instability of the foundation which I here lay.

The theorists, who maintained the existence of two fluids, gave their supposed opposite electricities the names of *vitreous* and *resinous*. They called the one *vitreous* because developed as they supposed in glass, the word being derived from a Latin term which denotes glass, and other resinous, because developed, as they supposed, in sealing wax, Gum Lac and the other resins, and those two were suppossed by them to possess properties entirely and inherently different from each other, each attractive to its opposite, and repellent to itself. Upon this hypothesis they attempted to explain the reason why an excited body attracts an unexcited body, and why like amounts of like electricities. either vitreous or resinous, mutuably repel each other.

But, as I shall be under the necessity, with my views of the subject, to differ entirely from their hypothesis, I will let them first speak in full for themselves, and then endeavor to show wherein that hypothesis clashes with fact. And that there may be no injustice done to those theorists, I will quote the language of one of their most learned and eminent champions. Dr. Turner, in his "Elements of Chemistry" on pages 72 and 73 thus speaks.

"On comparing the electric properties manifested by glass and sealing-wax when both are rubbed by a wollen or silk cloth, they will be found essentially different ; and hence it is inferred that there are two kinds or states of electricity, one termed *vitreous*, because developed on glass, and the other *resinous* electricity, from being first noticed on resinous substances. These two kinds of electricity, one or other of which is possessed by every electrified substance, are also termed *positive* and *negative*, the terms *vitreous* and *positive* being used synonymously, as are *resinous* and *negative*. The mode of distinguishing between positive and negative electricity is founded on the circumstance, that if two electrified substances are both positive or both negative, they are invariably disposed to recede from each other, that is, to exhibit electric repulsion ; but if one be positive, and the other negative, their mutual action is as constantly attractive. The end of a silk thread, after contact with an electrified stick of sealing-wax, is repelled by the wax, because both are in the same electric state; but if a dry warm wine-glass be rubbed with cloth or silk, and then presented to the the thread, attraction will ensue. A silk thread, in a *known* electric state, thus indicates the kind of electricity possessed by other substances : a convenient mode of doing this, is to draw a thread of white silk rapidly through a fold of course brown paper previously warmed, by which means its whole length will be rendered positive.

When two substances are rubbed together so as to electrify one of them, the other, if in a state to retain electricity, will be excited also, one being always negative and the other positive. It is easy to be satisfied of this by very simple experiments. Rub a stick of sealing-wax on warm coarse brown paper, and the paper will be found to repel a positively excited thread of silk, while the wax will attract it; if a warm wine-glass be rubbed on the brown paper, the glass will be positive, as shown by its repelling the positive thread, while the same thread will be attracted by the negative paper; friction of sealing-wax on a silk riband renders the riband positive, but with glass the riband is negative. If two silk ribands, one white and the other black, be made quite warm, placed in contact, and then draw quickly through the closed fingers, they will be found on separation to be highly attractive to each other, the white being positive and the black negative. The back of a cat is positive to all substances with which it has been tried, and smooth glass is positive to all except the back of a cat. Sealing-wax is negative to all the the substances just enumerated, but becomes positive by friction with most of the metals. The reader will perceive from these facts that the same substance may acquire both kinds of electricity, becoming positive by friction with one body, and negative with another. * * * * * * * * * * * * * * "This theory, the fundamental facts of which were supplied partly by Dufay, and partly by Symmer, is founded on the assumed existence of two electric fluids, which Dufay distinguished by the terms *vitreous* and *resinous* electricity. In order to account for electric phenomena by this supposition, the two fluids are assumed to possess the following properties:—They are both equally subtile and elastic, universally diffused, and, therefore, present in all bodies, possessed of the most perfect fluidity, each highly repulsive to its own particles, and as highly attractive to those of the opposite kind; these attractive and repulsive forces being exactly equal at the same distance, and both varying inversely as the squares of the distance varies. Electric quiescence is ascribed to these fluids being combined and neutralized with each other; and electric excitation is the consequence of either fluid being in excess. Their combination is destroyed by several causes, of which friction is one.—The application of these principles is as follows. Two unexcited contiguous bodies, A and B, are electrically indifferent to each other; for, though each electricity in A repels the electricity of the same name in B, attraction to the same extent is exerted between the opposite electricities, and no change results. If A and B are rubbed together, a portion of the combined electricities in both is decomposed, and the separated resinous fluid is transferred to one of them, suppose to A, and the vitreous to B, each being electrified to the same degree, though oppositely. The free particles of resinous electricity in A tend by their repulsion to recede from each other, and would quit A altogether, unless their passage were impeded by a non-conductor: the atmosphere, if dry, cuts off the retreat, and by its pressure confines the resinous fluid to the surface of A. The same happens to the vitreous fluid on the surface of B. But the opposite electricities fixed on A and B exert a strong mutual attraction, and may succeed either in forcing their way across the intervening stratum of air, or of actually drawing A and B into contact. In either case the free electricities reunite, and the electric equilibrium is restored.—On the contrary, if A and B are similarly electrified, that is, possess the same kind of free electricity, the effort of the electric fluid to escape in opposite directions causes the substances themselves to fly asunder, if the repulsive force exceed their weight, and thus produces electric repulsion.

This theory, as commonly stated, takes little or no cognizance of any attraction between the electric fluids and other material substances. But it would be against all analogy to suppose no such influence to exist; and indeed the supposition of an attractive force acting at insensible distances seems necessary to account for the impediment caused by non-conductors to the free movement of the electric fluids."

Dr. Franklin, the celebrated electrician of our own country took strong and decided ground against this doctrine. For it, he substituted the more simple theory of one fluid, and attempted to account for all the various phenomena of attraction and repulsion by the different states, or degrees, or volumes of electricity, which he called *plus* or *positive* and *minus* or *negative*. When a body had more than its natural share, it was considered to be in a plus or positive state, and when it had less than it's natural share, it was considered minus or negative. Bodies, upon this principle, are positive and negative relatively, or positive and negative *absolutely*. They are positive and negative *relatively*, when they are both plus, but when one ha greater amount than the other. They are positive and negative *solutely*, when one has *more* than its natural share and the other le But in each of those cases there is attraction, though much mo feeble in the former than in the latter case. Franklin, howeve found, after mature reflection upon the subject, that his theory wa attended with one inexplicable difficulty. His penetrating min could not solve it satisfactorily to himself. This difficulty was the repulsion of *two negatives*, which he confessed could not be explained upon the plus and minus theory, for, in this case, both would be minus, and there of course, be an absence of what he considered to be the attractive and repulsive principle.

Epinus, however, a celebrated electrician of St. Petersburg in Russia, undertook to extricate the theory of Franklin from this dilemma. He maintained, with Franklin, that there is but one fluid, and accounted for all the phenomena of attraction and repulsion, including the repulsion of two negatives, upon the hypothesis that there must be a reciprocal affinity or attraction between ponderable and imponderable matter, and that the particles of each must be mutually repellent to those of their own kind, and mutually attractive to their opposites, and that this attraction and repulsion exerts itself in the ratio of inverse proportions according to the squares of the distance. This it will be seen, lays the basis for three distinct propositions.

1st. The particles or ultimate atoms of ponderable matter naturally repel each other.

2d. The particles or component parts of imponderable matter or electricity mutually repel each other.

3d. The particles or component parts of both ponderable and imderable matter mutually attract their opposites, and that too with a force, which not only varies according to the squares of the distance, but, also, according to the magnitude and density of the one, and the volume or degree of the other.

Now, from this explanation of the difficulty, which Franklin encountered, I dissent altogether. It destroys virtually that "*vis-inertia*" or inaction, which is an essential property of ponderable matter, and gives to it attributes, which it never possessed. That difficulty can be explained in a manner more strictly in accordance with fact, for the theory of one electric agent, as maintained by Franklin, is correct, his doctrine of plus and minus is also correct, but there are certain invariable *results*, which depend upon the plus and minus of bodies, which will fully explain the difficulty, which he encountered. We must look, not to the simple volume or degree, or amount of accumulation itself—not to the simple plus and minus, but to the organic laws of the ultimate component particles of electricity, for the solution of the enigma, which so puzzled Franklin, which laws, however, invariably exhibit their operations through the medium of a plus and minus, as Franklin supposed; for all the electrical phenomena depend, after all, upon a plus and minus in bodies.

Owing to the extent of the present lecture, I am obliged to defer to the next the full examination of the two opposing theories, which have been stated, and shall show wherein I am under the necessity of differing from both, by the existence of a formidable array of facts, and the arguments which can be legitimately drawn from them, which facts and arguments, in my view, preclude the *possibility* of their being correct. The theory of two fluids in particular, seems to me so wide from the truth, and so contrary to known and tested laws, that I am somewhat surprized that men of such acknowledged talent and intellectual acumen, as they confessedly are, who advocate them, should ever have given them credence or currency. It must, we believe, in some cases, have been from the fact that they admitted, without examination, upon the mere authority of great names, what they should have thoroughly examined for themselves, unbiassed by preconceived opinions, and promptly rejected, if they found the same unsubstantiated by fact. It is unsafe either to regard great names as infallible

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or to indulge in fanciful philosophical speculations, whic solid and imperishable basis in the stern and sober reality Whether that stern and sober reality have an existence or n given case, can be ascertained, in most instances, by experin combatting those errors in theory, we shall draw all our co from the facts which experiment furnishes.

LECTURE III.

SUBJECT—COMMON ELECTRICITY.

As ANNOUNCED in the former lecture, the present will partake largely of a controversial character. Yet, we differ with those authors, from whose opinions we shall dissent, *only* because the facts, which have been ascertained by ourselves and by others, in the careful observations of the laboratory, compel us to differ. And, while we thus differ, we entertain the highest respect for the talents and researches of those eminent scholars. They have thrown great light upon many abstruse and difficult subjects, and we are free and happy to acknowledge the benefit and assistance which we have received from their works.

It is not at all wonderful that there should be diverse and clashing opinions upon the subject of electricity, and its various phenomena and influences, since it is an agent so extremely subtle, and since it must be acknowledged that it is not easy to detect, in many instances, the "*modus operandi*" of its doings, or the primary cause of some of the effects it exhibits. Our arguments and conclusions will, therefore, be liable to misapprehension and misinterpretation, unless great pains be taken to render them as clear and lucid as it is possible for language to make them, and, even then, we do not expect to escape entirely the common fate of authors, owing to the imperfection of the fallible medium through which ideas are conveyed from one mind to another. That we may, therefore, avoid as much as possible misapprehension, and that the positions to be examined, as well as controverted, may be vividly before the mind of the reader, we will restate them briefly, before proceeding in the discussion.

We shall do it, also, for another important reason. The opinions advanced in the following pages will be substantiated, or proved baseless and erroneous, as we establish or *fail* to establish our positions. Much, therefore, it will be seen, depends upon a thorough examination of the opposing and clashing theories of one and two electric agents, and upon the full and satisfactory establishment of the one, and refutation of the other, and, for this reason, we here define the precise positions of the combatants, even at the risque and expense of being thought somewhat diffuse and tautological.

Du Fay, Symmer, Coulomb, Turner and Thompson, promulgated and defended the theory that there are two kinds of electricity, or two distinct electrical agents—that one, if I can understand them aright, resides *inherently* in one substance and the other *inherently* in another—that each of those two agents is mutually repellent to itself, and mutually attractive to its opposite—and that all the phenomena of attraction and repulsion among bodies are produced by the action or agency of these two electricities.

That it may not be affirmed by the advocates of this theory, that I have misstated their opinions upon this point, when their glaring erroneousness and absurdity shall have been made to appear, or stand out prominently to view, even by *their own showing*, and their own *self-contradictions*, I will give their own language. Thomson thus speaks of this subject upon the 359th and 360th pages of his large work on Heat and Electricity.

"If we suspend two small pith balls, by means of a very slender wire from a stick of sealing-wax, and rub the wax with dry woollen cloth, the two balls will repel each other. If we suspend another pith ball by a slender wire from a stick of sealing-wax, and rub it also with a dry woollen cloth, this pith ball, if brought close to the two former, will also be repelled by them. If we suspend the pith balls by slender wires from dry glass tubes, and rub the tubes with dry woollen cloth, the result will be the same—all the pith balls will repel each other."

But if we suspend a small pith ball by a small wire from a glass tube, and another, in a similar manner, from a stick of sealing wax, and make the two balls approach, after having rubbed the glass tube, and the stick of sealing-wax, the pith balls, instead of repeling, will *attract* each other."

Now these facts. which Thomson records, as having been proven by experiment, we pretend not to deny. They are doubtless true. But we deny, altogether, the conclusions, which he draws from these, as his data or premises. He thus reasons.

"Hence it is obvious, that the electricity excited in glass" [now mark this] "is *different* from that excited in sealing-wax, since bodies having the *electricity* of *glass* attract those having the electricity of sealing-wax, while bodies having each either the electricity of glass or sealing-wax repel each other."

Now it has been affirmed by some of the advocates of the theory of two agents, that Thompson did not say, in this passage, or *intend* to say, that glass produces *only one kind*, and sealing-wax *only* the other. But if he does not, by the quotation already made, advance such an opinion, I must confess myself utterly incapable of understanding his language. My intellectual acumen happens not to be sharp enough, if that be the case, to perceive his meaning. Let us examine and dissect the passage a little, for our object is to get at the facts in the case, and elicit truth, and sift it from error. Thomson expressly affirms, without any qualification, that the electricity of glass is *different* from that of sealing-wax. He does not intimate that he considers it to contain any other, than that which he says is different. The assumption that he does, for the sake of getting him out of a dilemma, is supplying, by an active imagination, what he has not seen fit even to *hint* at in any of his labored works. Before showing what that dilemma is, from which his apologists would extricate his theory—before placing in striking contrast his palpable *self-contradictions*, and making him refute himself, scholar as he certainly is, I will quote from Turner, another of the most able defenders of the theory we are opposing, to show that Thomson stands not alone in the advocacy of such sentiments.

He says, on page 72 of his Chemistry, as quoted in a former lecture, "on comparing the electric properties manifested by glass and sealing-wax, when both are rubbed by a woollen or silk cloth, they will be found *essentially* different, and hence it is infered that there are two kinds or states of electricity, one termed *vitreous*"—and why? Mark the answer of Turner—"*Because* developed in glass. And the other *resinous*"—and why?—"Because first noticed in resinous substances." Now, is there the slightest intimation in this statement of the theory, that glass ever develops but one kind, or resinous, substances either. Does he not rather expressly affirm that *they* are *essentially* different, and if one thing be *essentially* different from another, what logician will insinuate that they are both alike?

Now then for the self-contradictions of the staunchest and most learned advocate of this palpable error in theory. Let Mr. Thomson be arrayed against Mr. Thomson, and let him be refuted by his own statement of facts. There can be no *fairer* system of polemic warfare.

On page 361 of Thomson, he has the following language. "If we rub dry woollen cloth against smooth glass, it acquires negative or resinous electricity: while the glass becomes *positively* electrified. But if we rub woollen cloth against rough glass, it acquires positive electricity, while the glass is charged with negative or resinous electricity."

Now in this quotation Thomson certainly contradicts his assertions in other parts of his work, if I am able to decypher the meaning of an author. He affirms in the quotation already dissected and anallyzed, that "the electricity of glass is *different* from that of sealing-wax. and in the facts last quoted, he proves that, with the same materials and with the same rubber, both the electricities are developed in glass, and that at least one of its electricities, if it have two, is the same as in sealing-wax, instead of being "*essentially different*," as elsewhere asserted.

This palpable *self contradiction* arises from the fact, that he has undertaken to defend the fanciful speculations of an active imagination, which, as a general thing, passed in his day too much for current truth.

But, some one may say, that, although a palpable contradiction has been detected, yet that that should not impair confidence in the doctrine of two agents. Such an one may affirm that by rubbing glass, one kind of electricity may be drawn from it, and that by rubbing with the same rubber, glass of another kind of surface, another kind of electricity may be developed. Although the bare proposition to my mind seems most superlatively illogical and ridiculous, yet I will examine it, because it seems to be seriously, and honestly believed by its advocates. If it be maintained that there are two electric agents or *fluids*, as they are called, and that they have an attraction for each other, and a repulsion for themselves, they must, according to the facts, which Mr. Thomson himself has recorded, both reside in glass. Now, if that be the case, and if they both, as asserted, have a mutual attraction for each other, why should friction call the positive current out of smooth glass and leave the negative, or why should it call the negative current out of rough glass and leave the positive? It may be said by some one, perhaps, that it *does* call both out, but that the one current runs to the surface of the woollen rubber, while the other accumulates upon the surface of the glass. But why should they do this? If there be two currents of the kind, we are examining—if they have a *mutual attraction*, for each other, and, if friction calls forth both of them at the same time, why should they not, by the force of that attraction, both accumulate upon the same surface? And to show still further, the mere fanciful nature of this theory when brought to the test of fact, and of reason, why should a dry woollen rubber accumulate upon itself negative electricity, when rubbed against *smooth* glass, and positive electricity when rubbed against *rough* glass, and why should the smooth glass acquire positive and the rough negative at the same time. Not one of these questions can be answered satisfactorily upon the supposition of two fluids.—We have to resort to the theory of one fluid to account for these things rationally, though not to the theory of one fluid, exactly as taught in the books. Positive and negative does not depend upon the influence of two electricities inherently different, but upon the different degrees of the accumulation of a single current. If a substance, by any cause, acquires *more* than a certain amount, so as to make it plus, with regard to what may be called its natural share, it is positive, but if it have less than a certain amount, so as to make it *minus*, it is negative, and so positive and negative relate to degree or quantity, and to degree or quantity *alone*. Upon this hypothesis, the reason why, in the facts quoted from Thomson, the woollen became positive in one case, and the glass negative, and why in the other case, the woollen became negative, and the glass positive, was simply because the roughest of two substances, when rubbed together, if both be non-conductors, will impart its electricity to the other, and make that plus or positive, while it becomes minus or negative, and just to the extent that the one is positive, just to that extent, is the other negative; so that the one invariably accumulates precisely what the other loses. *This law is universal.* If one substance loses its electricity, just in that proportion *precisely* does the other accumulate it. Not an iota is created by friction. Its quiet is only disturbed, and, if it accumulates, it is evident that the substance, from which it is accumulated is so far minus.

This accounts rationally, and in accordance with that simplicity and economy, which appears throughout nature, for all the phenomena of positive and negative electricity. It is simply accumulation and proportional abstraction. But the reason why two positives repel, a positive and negative, and a negative and positive attract and why two negatives repel, is much more abstruse. It has, for a long time, puzzled philosophers. Franklin, clear headed as he was, found himself in a dilemma, and confessed it, when endeavoring to solve the mystery of the repulsion of two negatives. Nor is the attempt of Epinus to extricate him from the difficulty, entirely satisfactory, although I far prefer it, to the irrational and palpable contradictions, which cluster thickly around the theory of two electric agents. The opinions of Franklin, reconciled by Epinus, are based upon those three propositions, which I stated in a former lecture.

1st. Ponderable matter repels its own particles.

2d. Imponderable matter repels its own particles.

3d. They have a mutual attraction for each other.

But this again might seem to convey the idea that ponderable matter, by its attraction, exhibits inherent activity, which is contrary to fact, for ponderable matter of itself, I hold to be perfectly inert.—We must examine further, then, to find a philosophical solution for the enigma. Such a solution I think I have found. It is no where even hinted at in the books. But because it is not, let no one suppose that I am about to advance a mere fanciful hypothesis, based on no solid foundation of fact. My solution of the difficulty will be derived from a law of electricity, which, although it seems to have escaped the attention of chemists, can nevertheless, be demonstrated to exist, as easily and as perfectly, as any problem in Euclid, can be demonstrated. It is this. Every ultimate particle of electricity has opposite polarities—that is, each end of each individual particle has a different property—*like* ends or polarities repel, and *unlike* ends or polarities attract. This I intend to prove conclusively, by the aid of that immutable truth, that *the laws of a whole are the laws of its parts,* and by the operation of the rule, so proven, I intend to show that all the phenomena of attraction and repulsion among both atoms and planets, can be rationally accounted for.—Let us apply the immutable and infalible rule, that the laws of the whole are the laws of its parts, and *see* whether it will sustain the opinion we have hazzarded, and for which we derive no support from the books.

Electricity and galvanism are, at the present day, generally conceded to be the same agent. There is no dispute about that.—Now, if you pass a current of galvanism around soft iron, bent into the form of a horse-shoe, and wound spirally, with insulated copper wire, you make the iron magnetic, and the two ends have different polarities. By different polarities, I mean, that, what one end will attract the other will repel, or the one is negative and the other is positive. But by changing the poles of the battery and passing the current of electricity in a different direction around the spiral wire, you change the polarity of the iron, and make the end that was positive, negative, and the end that was negative, positive, which can be shown, by experiments in electro-magnetism. So then positive and negative, in this case, depend upon the direction in which the current runs, for the current runs *inward* at one end and outward at the other. The end where the current is *inward* is *always negative,* and that, where it is *outward* is *always positive.* And why is this invariably so. There must be a reason for this phenomenon.—Its solution is readily found in the admirable rule, that the *laws of the whole are the laws of its parts.* If a current of electricity, running in a certain direction, makes one end of a bar of iron positive, and the other negative, each individual ultimate particle of that current must have an agency in producing such a result, and, therefore, each individual particle must have a positive and negative end, the positive end always leading, and the negative, of course, always following. We infer this from the fact that the laws of the whole, are the laws of its parts, or the laws of its parts are the laws of the whole; for it would be utterly impossible that the whole of a thing should have a quality the *opposite* of the *parts* of which it is composed.

To make our position still more impregnable by fact, and argument, let us examine further. If you pass the galvanic current around steel spirally, in the same way as it is passed around soft iron, you make it permanently magnetic, the end, where the current is *inward*, is *negative*, but the end where it is *outward is positive*. So it will remain for years. Now you may cut up that bar of steel, which is thus made magnetic, into ten thousand *pieces* and *each piece* will have a positive and negative end, and the positive and negative polarities of the pieces will be arranged in the same direction as in the whole. What, then, is the unavoidable and logical inference? Why, that *each ultimate particle of the electricity*, that made it magnetic and kept it magnetic, has *opposite polarities*, as well as the whole current;—because the polarities of the whole are, most assuredly, made up of the properties of its parts. A mere thimble full of the atmosphere, for instance, contains its relative proportions of oxygen and nitrogen, as well as the whole mass. A drop of water contains its relative proportions of oxygen and hydrogen, as well as the ocean, and so with every thing else. Further confirmation if confirmation it needs, will be given to this opinion, when we come to the subject of polarized light.

Having by fact, and by argument, attempted to prove that each end of the ultimate particles of electricity has opposite polarities, that the positive end is always presented in the outward current, and the negative end, of course, in the inward current, we will now apply this theory to the explanation of the phenomena of attraction and repulsion. But first, to show that the facts are true, which we have stated, we can prove them by an experiment with two magnets.

If, for illustration, two steel magnets, with like powers, be dipped into iron filings, until they have accumulated as large an amount, as they can retain upon their poles, and the opposite poles of each be then presented within a short distance of each other, the filings will spin out, and fill up the space between them, and exhibit an oily, ropy appearance. But, if like poles be presented, the filings will be blown back, as it were, and stand out like hair around the points of the magnet. This shows that there is attraction in the one case, and repulsion in the other.

Now then, for an explanation of the attractions and repulsions of common electricity by this theory. A body which is charged plus or positive, has an emanation or an outward current. Such a body will attract a body charged minus or negative. And why? Because, as we have shown by the magnets, the outward current of the body charged plus presents its positive end. But a body in a minus state has an inward current of electricity, which it attracts from contiguous substances. Of course the negative end of the ultimate particles of this inward current is presented. And what is the consequence? Why two bodies, the one having an outward, and the other an inward current, present opposite polarities to each other, and are attracted from the operation of the immutable law, that opposite polarities attract.

We now come to the solution of that difficulty, which perplexed Dr. Franklin so much—the repulsion of two negatives. Before the application of this rule the difficulty vanishes at once. When two bodies are minus or have *less* than their natural share, the current of electricity is inward into both. Now if, while the two currents are inward, the bodies in a minus state be brought near each other, they are repelled, because both currents being inward, the negative ends of the ultimate particles of each current are presented to each other, and they are repelled upon the principle that like polarties repel each other. Thus is all attraction and repulsion among material bodies and, of course, all motion produced by the agency of electricity alone, without the intervention or co-operation of inert matter. So that the difficulty, which Dr. Franklin encountered in his theory of plus and minus, is obviated without the aid of the unphilosophical assumption of Epinus and Cavendish, that matter has the property of repelling its own particles.

But an objection may possibly arise in the mind of some, respecting the repulsion of two negatives, which I will state in the form of a question, and then answer it. If the current of electricity be *inward* into two bodies, why should not the force of the currents setting in, bring two bodies together? Such a question would be asked by an objector, who did not understand fully the relative agency of electricity over inert matter. Motion is never produced in ponderable matter by the mere force of moving currrents of electricity. If this was the case, our earth would have been instantaneously battered to atoms by the light, which first struck it from the sun. The force of the currents is not a moving cause at all. So subtle are they, that they make no impression of this sort upon matter. But their attractions and repulsions all depend upon an organic law of the ultimate particles—upon polarity, and upon that alone.

There are several other facts illustrative of this law. The uper end of a lightning rod, for instance, is negative, while the lower end is positive. And why? Because the current is towards the earth, and is, therefore, inward at the top and outward at the bottom. Unless this were the case, it would not have a tendency to draw electricity from the clouds, but repel it.

The shovel, tongs, poker or any other metalic rod or substance which has stood for some time in an upright position, whether in the chimney, corner, or in any other upright position—whether within or without the house—imbibe electric properties, and their two extremeties always exhibit opposite polarities. This is demonstrated by the fact, that one end will draw the north point of the needle of the compass, while the other end will drive it.

As opposite polarities always attract, we find by this experiment, that the top of such a metalic rod is negative, because it attracts the positive end of the needle, and the bottom positive, because it repels the north point of the needle, upon the principle that like polarities repel.

The longer a metalic rod remains in an upright position, the stronger does its electric, or magnetic properties become, until it has become as completely saturated with the wondrous agent, as it can be. Now the question naturally suggests itself, as to the exciting cause of this invariable electric, or magnetic property. Why is the top of a metalic bar or rod, which has stood in an upright position for a long time, always negative, and *its bottom* always positive, *or in other words, why is the stream of electric influence always* *inward* at the top, and *outward* at the bottom? Whence does it come? From the sun, undoubtedly, in the passage of the rays of that electrifying agent to the earth, as we shall show more fully when we come to the subject of light. If any chemist can account for the phenomenon, more philosophically, we should be pleased to have his solution of the problem.

Having fully and minutely examined the theory of one, and two fluids, and described what we consider to be the true and *only* true cause of all attractions and repulsions in nature, we must now, in order to render a treatise upon this subject *complete*, just glance at some of the principal benefits, which have been conferred upon the world by the investigations of electricians, which investigations, were some of them made at great personal risque, as will appear in the sequel.

The Leyden Jar is an article of electric apparatus, which was invented by Cunæus, Muschenbrœck and Allamand, at a very early period of electrical science. But, as it is in common use, in all experiments, illustrative of this subject, and as it is fully described in the text books, we shall just pass with a mere allusion to it.

After its discovery, and the exhibition of the powerful effects of electrical batteries, philosophers could not avoid perceiving the analogy, which evidently exists between electricity and lightning.—This led to intense investigations of the subtle phenomenon of the storm cloud. Our sagacious Dr. Franklin led the way. Having discovered that pointed rods of the various metals have the power of discharging electricity, when presented at some distance from the knob of the Leyden jar, the thought occurred to his mind, that atmospherical electricity, might, by means of that discovery, be made *sensible*. This thought was communicated to M. D'Abilard, of France, and some other electricians of Europe, with the request that they would test the correctness of his opinions by some experiment, as their facilities for procuring suitable apparatus, were superior [illegible] his own. Following his suggestion, observations were eagerly made by several, and his opinions were proven to be well founded.

In the mean time, however, and before he had received any account of the experiments made in Europe, it occurred to Franklin, that, by means of a common kite, he could have access to the floating reservoirs of thunder. Having, therefore, prepared one, with a large silk handkerchief, having two cross sticks, he, with no confident but his son, for fear of the ridicule, which would attend an unsuccessful experiment, walked out into a secluded field at the approach of the first thunder storm, and with the help of his son, raised it into the atmosphere. He waited some time with anxious and breathless expectation. One well charged cloud had passed, and no effect upon his kite was perceptible. Just, however, as he began to despair of success, he noticed that some of the loose threads around his hempen cord, which had, by this time, become a better conductor than at first, owing to the moisture accumulated upon it, would stand out, and apparently avoid each other. Encouraged by this favorable appearance, he presented, though at the risque of his life, his knuckle to the key, which he had tied to the end of the cord, and received a strong spark, attended with a loud snap. Others more brilliant still and in quick succession followed, and thus was fully proven by Franklin, the identity of electricity, and the lightning of the clouds.

This experiment was unconsciously attended with extreme danger, as was subsequently proven in the fate of the amiable, talented and lamented Professor Richman, of St. Petersburgh. The circumstances of his untimely end are thus detailed by Thomson, in his large work on "Heat and Electricity," on pages 435—6.

"He had provided himself with an instrument, which he called an electrical gnomon, the use of which was to measure the strength of electricity. *It consisted of a rod of metal, terminating in* a small glass vessel, into which he had *(for what reason does not appear,)* put some brass filings. At the end of this rod a thread was fastened, which hung down by the side of the rod when it was not electrified, but when it was, it avoided the rod, and stood at a distance from it, making an angle at the place where is was fastened. To measure this angle, he had the arch of a quadrant fastened to the bottom of the iron rod.

He was observing the effect of the electricity of the clouds, at the approach of a thunderstorm, upon his gnomon, and of course standing with his head inclined towards it, accompanied by M. Solokow, (an engraver, whom he frequently took with him to be a joint observer of his electrical experiments, in order to represent them the better in his figures,) when this gentleman, who was standing close to his elbow, observed a globe of blue fire, as he called it, as big as his fist, jump from the rod of the gnomon, towards the head of the Professor, which, at that instant, was about a foot distant from the rod. This flash killed Mr. Richmann; but Mr. Solokow could give no account of the particular manner in which he was immediately affected by it.—For at the same time that the Professor was struck, there arose a sort of steam, or vapour, which entirely benumbed him, and made him sink down upon the ground; so that he could not remember even to have heard the clap of thunder, which was very loud.

The globe of fire was attended with a report as loud as that of a pistol. A wire, which brought the electricity to the metal rod was broken to pieces, and its fragments thrown upon Mr. Solokow's clothes. Half of the glass vessel, in which the rod of the gnomon stood, was broken off, and the filings of metal that were in it, were thrown about the room. The door case of the room was split through, the door torn off, and thrown into the room. The shoe of the Professor's left foot was burst open, and there was a blue mark on his foot at that place. From which it was concluded, that the electricity had entered by the head, where there were evident marks of injury, and made its way out again by the left foot."

I cannot resist the inclination to make another quotation, here, from the same work, respecting the improvement, made about this time, and which rendered experiments with the kite much more safe and satisfactory, than before.

"M. de Romas made the experiment with the kite in a more perfect manner, than the first attempt of Dr. Franklin. He twisted a fine iron wire into the cord of the kite. To prevent the observer from being exposed to danger, the lower extremity of the string terminated in a silk cord, eight or ten feet in length, by means of which the kite with its string was insulated. Instead of drawing sparks with the finger, which makes the observer himself receive the charge, he received them by means of a metalic conductor, connected with the ground by a chain, which he held in his hand by means of an insulating glass handle, so that it resembled our common discharger. Romas describes the sparks given out from the string to this discharger during a thunder storm, in a letter to the Abbe Nollet, in very glowing language. "'Conceive,'" says he, "'Plates of flame, nine or ten feet long, and an inch thick, which make as much noise as a pistol. In less than an hour I had certainly thirty plates of this size, without reckoning a thousand others of seven feet, and below that. But what gave me the greatest satisfaction in this new spectacle, was, that the greatest of these plates were spontaneous, and that notwithstanding the abundance of the fire which they contained, they fell always on the nearest conductor. This constancy gave me so much security, that I was not afraid to draw sparks by means of my conductor, even when the thunder storm was at its height, although the glass handle of that instrument was only two feet in length. I conducted where I pleased, without feeling in my hand the smallest commotion, sparks of fire six or seven feet long, with the same facility as those whose length did not exceed seven or eight inches.'"

From these successful experiments with the kite, the *practical* benefit of lightning rods, for the protection of edifices exposed to the destruction of the scathing element, was suggested to the active mind of Franklin, who seemed to be always studying to turn science to a profitable account. These were made, by elevating above the highest dome, or spire, or the chimney of a dwelling, a rod with one or more sharp points, to abstract the fluid from the surrounding atmosphere, in most cases, *silently*. Down the sides of the edifice, these were conducted, and passed into the ground, to a considerable depth, being fastened to the walls of the building by iron staples, driven into them, with some non-conducting substance between them and the rod, to prevent the passage of a bolt into the wall, where the staples entered, when the rod happened to be struck by a perceptible flash.

Great improvements have been made, since the invention of Franklin, both in the construction of lightning rods, and in the method of putting them up. By such improvements, they have become much better protectors. They are now made, in some parts of our country, out of square nail rods, with bearded corners, each joint made with a ring at one end, and a shank at the other, turned outward about two inches, at right angles with the rod, and pointed, which, when put up, is turned outward from the building and inserted in the ring. Thus, each joint, six or eight feet long; has a ring at one end, and a shank at the other, which, when connected together, constitute the upright rod. In addition, a square nail rod is sometimes extended the full length of the ridge pole, with perpendicular spikes, having sharp points about six inches long, attached to it at an interval of every two or three feet, with branches attached to the same, extending above, one or more of the chimneys, if the building be a house, or above the spire, if it be a church, and these, so constructed, are connected with two upright rods, erected in the manner before described, at each end of the house, or edifice. and passing into the ground. Such rods are an ample protection against any thunder-bolt, whether its passage be perpendicular or horizontal.

It might seem appropriate, before closing this lecture upon common electricity, that I should describe the various causes of electrical excitement, show the chemical effects of this powerful and all pervading agent, and give a solution for the phenomena of winds and storms? But the two former will be reserved for the lectures upon Galvanism, and the latter for those upon Caloric.

I shall, therefore, close with the request that the reader would keep distinctly in view, the laws, by which common electricity is governed ;—for, by arguments and illustrations, based upon those simple and uniform laws, I expect to establish, beyond controversy or reasonable cavil, the positions which I shall take, in discussing the more abstruse and difficult topics of some of the following lectures. Yes, I shall depend upon those laws, to prove that electricity and electricity alone, is the prime natural cause of all chemical changes in creation, and all motion among either atoms, or spheres, or constellations of spheres. I thus call the particular attention of the reader to those laws of electricity, because it will doubtless be the case, that many will hesitate to give the theory credence, and persist in that hesitation, until convinced by demonstrations, which are founded upon the self evident proposition, that "like causes produce like effects."

LECTURE IV.

SUBJECT—GALVANISM.

By minute and careful investigation, and by a variety of practical experiments with apparatus, we have, thus far, ascertained the immutable laws, by which the electrical agent is governed. By this investigation we have ascertained that it can be readily excited, and brought from its mysterious repose into action by friction,

"Quick as spark from smitten steel,
"From nitrous grain the blaze."

Well might its singular developement astonish those who first beheld it; for a kind of enchantment seems to linger around the subject. By its instantaneous production, upon the proper application of an exciting cause, we are forcibly reminded of the fabulous legends of magic, though we know it to be reality, and not fable. The enchanted ring of Mustapha, the African magician, or the wonderful Lamp of Alladin, when rubbed, brought into the presence of the holder, one of the monstrous Genii of the fables, irresistibly strong but yet perfectly docile, and submissive to the will of the person, who thus called him. In the same manner when friction is applied to the cylinder of glass, forth leaps instanter, the subtle and irresistible agent into action and visibility, strong but yet docile as the fabled Genii, a slave to the will even of an intelligent child, standing ready submissively to obey his dictation, and to do his pleasure, if bidden in accordance with its organic laws.

We have ascertained also, that, under certain circumstances, it invariably exhibits an attractive, and under other circumstances invariably a repulsive power, and that this attraction and repulsion is the cause of all the motions among the particles and light bodies of inert matter—that neither the theory of two fluids, as taught by Turner, Thomson and others, nor that of one fluid as taught by Franklin, with the superadded hypothesis of Epinus and Cavendish, account rationally and philosophically, for the cause of attraction and repulsion—that that cause is to be found in the constitutional organic laws of the ultimate particles of electricity—that each ultimate particle has opposite polarities, from the fact that a current has opposite polarities and from the self evident axiom that the laws of the whole are the laws of its parts; that the outward current or emanation, is always positive, because the positive end of the ultimate particles of that current is always presented—that the inward current *is, upon the same principle,* always negative, because the negative end of its ultimate *particles, is always presented*—that two outward currents always repel each other, because the positive pole of the ultimate particles of one current, are presented to the positive pole of the ultimate particles of the other, and that two inward currents repel for the same reason, because like polarities always repel whether both be positive, or both negative, that an outward current, and an inward current, when presented to each other, always attract, from the fact that the positive and negative end of the ultimate particles of those two currents are then presented to each other, and unlike polarities, or positive and negative polarities always attract. Before this theory, which is capable of absolute demonstration, if there be any certainty in reasoning from the data of selfevident propositions, all difficulties vanish, and every phenomenon of attraction and repulsion can be accounted for philosophically.

It was assumed at the commencement of this course, that all the imponderables are one, and the same agent. This we expect to prove to a demonstration, if we can prove that they are all governed by the very same constitutional or organic laws, and that their offects resulting from the operation of those laws, are the same, which we shall certainly do, if there be any truth in that fundamental principle of logic, that like causes produce, like effects. Having, then, ascertained the laws, and agencies—or the causes and effects of the phenomena produced by this indivisible imponderable principle, under one of its appellations, or in one department of its wondrous operations, we will proceed to the examination of the department next in order, which is denominated galvanism. Its history would be the first appropriate object of attention and remark.

Galvanism, is so called from Galvani, Professor of surgical anatomy at Bolgna, who was its reputed discoverer, and a scholar of considerable eminence. Like several other important branches of science, it owes its origin to an accident, which occurred in the year 1791. These were the circumstances of that accident. Mrs. Galvani, at a certain time, during the absence of her husband, observed the effect which electricity exerts upon the muscles of dead animals, through the medium of the nerves, from the accidental contact of the conductor of an electric machine with the crural muscle and lumbar nerve, of a frogs leg, which had been dressed for food, and was lying upon a table near the machine in the professors laboratory.—This contact immediately produced violent convulsions in the frog. These, Madam Galvani happened to observe, and related them to her husband upon his return. As he was at that time investigating the subject of animal electricity, he seized upon the idea with avidity and repeated the experiment in a variety of ways with success. And thus although Galvani, is the reputed author and originator of this science, yet it is to an intelligent and observing Lady that the world is doubtless indebted for the discovery of the powers of Galvanism.

In connection with this subject, it is worthy of remark, that, in the history of the rise and progress of some of the most important sciences, some very trivial circumstance or mere accident has been the prime cause of surprising results and developements. It is some where recorded, that Sir Isaac Newton was first led to those sublime investigations which overturned the old Ptolemaian system of philosophy, by a circumstance so simple as the fall of an apple, which suggested the subject of gravitation. The furious and forceful ebullition of a boiling tea kettle, gave rise to a train of thought, which resulted in the invention of the steam engine, and in the propulsion of steam boats and locomotives, and the same may be said of many other useful inventions. Not only was the science of Galvanism discovered by chance, but accident also led to the present arrangement of galvanic batteries.

Upon metalic hooks, which were attached to the iron pallisades of Galvanis' garden, frogs happened to be hung up by the spine, after they had been dressed, as in the former case, for food, (as frog soup in those days, and in those countries, was regarded as a very dainty dish, although, our epicureans might wonder at their singular tastes.) Whenever by the blowing of the wind, or by any other cause, the frogs were made to swing, so as to touch occasionally the pallisades, they were thrown into convulsions. The Professor, who observed it, was, at first, quite puzzled to account for the phenomenon. He, however, imputed it to animal electricity. Professor Volta of Paris objected to this conclusion, and affirmed that it must be the effect of the electricity produced by the contact of two metals, and that the muscles and nerves of the animal, were only the medium, through which it was conducted, and that the convulsions were produced by the effect of that electricity upon those muscles and nerves. This conflict of opinion with opinion, and intellect with intellect, and the truths and facts which were elicited by the controversy, resulted, at length, in establishing the theory of Volta, that by forming a certain connection between different metals, electricity is produced.

The simplest galvanic arrangement is that in which a piece of zinc is placed beneath the tongue, and a piece of copper above it. Then, whenever the edge of the two metals, thus situated, is brought in contact, there will, whether the eyes be opened or closed, be perceived a slight flash of galvanic light. This flash will be produced, as often as the metals are separated and brought in contact again.

By putting a strip of zinc, and one of copper into a tumbler of acidulated water, and bringing the two in contact at the top, galvanic effects are produced; or, if they be set upright in the glass, and separate from each other, and, in that position, be connected by means of two wires soldered to the two plates, which wires are called poles, the same galvanic effects are produced.

The effects, which are produced by an arrangement so simple, are, however, imperceptible by any of the ordinary processes by which we ascertain the existence of a galvanic current. There will be perceived no sensible flash, if the circuit be broken and closed alternately, through mercury. *No shock will be felt by the experimenter, as he forms a part of the circuit, nor will any effect be produced upon the muscles and nerves of animals.*

There is, however, an article of apparatus, called a galvanometer, or galvanic Multiplier, which was invented by Schweiger, for the purpose of detecting and ascertaining very minute currents of galvanism, and their strength or intensity. This instrument is composed, in the language of Turner, of a copper wire "bent into a rectangular form consisting of several coils, and in the centre of the rectangle is placed a delicately suspended needle. Each coil adds its influence to that of the others; and as the current, in its progress along the wire, passes repeatedly above and below the needle in opposite directions, their joint action is the same. In order to prevent the electricity from passing laterally from one coil to another in contact with it, the wire should be covered with silk. The ends of the wire, are left free for the purpose of communication with the opposite ends of a voltaic circle. When a single needle is employed in the experiment, its movements are influenced partly by the earth's magnetism, and partly by the electric current. The indications are much more delicate when the needle is rendered astatic, that is, when its directive property is destroyed by the proximity of another needle of equal magnetic intensity, fixed parallel to it, and in a reversed positon, each needle having its north pole adjacent to the south pole of the other; in this state the needles, neutralizing each other, are unaffected by the magnetism of the earth, while they are still subject to the influence of galvanism. For researches of delicacy, the needles should be suspended by a slender long thread of glass, and the deflecting force measured, not by the length of the arc traversed by the needle, but by the torsion required to keep the needle at a constant distance from the wire, as in the torsion electrometer of Coulonmb.

The mutual influence of a magnetic pole and a conducting wire changes with the distance between them. Experiment shows that the action of a magnetic pole and a continuous conductor, every point of which exerts a separate energy on the pole, varies inversely as the distance. This result justified the opinion, that the force of a magnetic pole on a *single* point of a conductor varies as the square of the distance, the same law which regulates the distribution of heat and light, as well as the effects due to electricity.

It is not absolutely necessary that there should be connected together two plates to produce a galvanic current. A simple voltaic circle may be formed by *one* metal and *two* liquids, so arranged, and possessing such different degrees of decomposing power, that one side of the metal shall be acted upon more intensely by the decomposing agent than the other. In order to test this, let a piece of zinc, for instance, be cemented into a box, so as to leave a cell on each side of the plate. Then, by putting a solution of salt into one cell, and nitric acid into the other, a positive current will run from the cell containing the solution of salt, if the liquid of the two cells be connected by means of a metalic conductor. And galvanic excitement can be produced even with *one* metal and *one* solution, possessing the same decomposing power, provided that the acid in one of the cells be warmer than that in the other ; in which case, the warm acid will decompose the zinc more rapidly than the cold, and, of course, a current of positive electricity will set from the side of the plate affected by the warm acid, round to the side affected by the cold.

From the facts developed by the above experiment, it must appear evident to every one, that galvanism affords no support to the theory of two fluids. There is evidently but one current, and that appears, as is abundantly shown by this apparatus, to depend upon a plus and a minus. The side affected by the warm acid decomposes the zinc the most rapidly, and is, therefore, plus with regard to the other side, which decomposes less rapidly. The current, of course, runs from the plus to the minus, in accordance with an immutable and universal law of nature. For what is that current—what, in fact, is galvanism, but the latent caloric, of the metal set free by the combined action of its own powers and those of the acid ?—And why does the current run from the plus to the minus, if it be not in obedience to a law of caloric, which always seeks to restore and keep up an equilibrium in nature ? It certainly must be in obedience to such a law, and we do not believe that any chemist can philosophically and rationally account for it in any other way. It must be something which is set at liberty by the decomposition of the zinc, and the more rapid the decomposition, the greater the amount set free. If that agent, thus set free, be not latent caloric, it would puzzle a philosopher to define what it is.

The current of a battery always runs from the electro-positive metal to the electro-negative, because the electro-positive metal is always rapidly decomposed by the action of the acid, while the electro-negative is scarcely affected at all. The latent caloric, being set free, obeys, therefore, the immutable law of free caloric, and runs from a plus to a minus, and that constitutes galvanism. If this be true, as it doubtless is, it annihilates the last vestige of support for the theory of two fluids, and proves to a demonstration that there is but one. So impressed was Turner, with the fact that Galvanism furnishes no support for the doctrine of two fluids, that he seems to have abandoned it, in a measure, in his explanations of the passage of the galvanic current. He says, on page 88 of his Chemistry:—" A current of negative electricity, agreeably to the theory of two electric fluids, ought to traverse the apparatus in a direction precisely reversed; but for the sake of simplicity, I shall hereafter indicate the course of the positive current only.

A still more efficient arrangement, but yet a very simple one, it being one of the first inventions in the infancy of the science, consists of a series of glasses, or glass tumblers, connected with each other by a metallic arc, with a piece of zinc at one end and a piece of silver or copper at the other. These glasses are filled with some saline or acidulated solution, as salt water, or sulphuric acid, or diluted sulphate of copper, and the circuit is then closed by the experimenter, by putting the fingers of one hand into the glass at one extremity, and those of the other into the glass at the other extremity. In this situation a person will receive a shock every time he replaces his fingers after removing them.

Another very cheap and simple galvanic arrangement can be made by taking a number of pieces of common window glass, three or four inches square, and after coating them on one side with zinc foil, and, on the other with copper or silver foil, by placing them upon each other, the two opposite metals always in contact, taking the precaution, however, when coating the glass, not to let the metals cover its entire surface. Each additional plate of glass, thus coated, will increase the electric influence of such a pile, but yet, some thirty or forty must be so connected, in order to give any degree of intensity.

Instead of using glass, which is a non-conductor, if we use discs of paper, which is an imperfect conductor, similar electrical phenomena will be produced, though some what more intense, with a given number of coatings of zinc and copper foil. To construct such an apparatus, the most convenient method is to cut the paper into round pieces about the size of a half dollar, suitable for admission within a good sized glass tube, after having coated them on each side with zinc and copper foil, observing to have the coat of zinc always downward and that of copper always upward. or that of copper always downward and that of zinc always upward, which is immaterial. The tube should be long enough to hold one or two thousand of those discs, and the two ends be closed with some metalic plate in contact with the discs, provided with connecting wires or poles The zinc end of such a pile is always positive and the copper end always negative. And why? Because the current is always outward from the zinc, and inward to the copper, which shows that, relatively, with regard to each other, the zinc is always charged plus, and the copper minus.

Such an apparatus, as we have described, constituted what has been called the dry columns of Zamboni and De Luc, two of which the latter constructed, and, having placed them near each other, so that the positive pole of the one would correspond with the negative of the other, he suspended between them an insulated bell, with an insulated ball on each side, which kept up a continual ringing for years, with only now and then a slight intermission. A light insulated needle properly arranged, and balanced upon a pivot, would oscillate continually between them.

The next improvement in the construction of galvanic apparatus, and one which Thomson remarks, "should be ranked among the greatest discoveries, from the enlargement which it has given to our knowledge of electricity, and its effects, and the extension and perfection of chemical science, is the voltaic pile, so called from Volta, Professor of Natural Philosophy, at Pavia. If we compare the state of Chemistry before the discovery of the voltaic pile, with its present aspect, we cannot but be astonished at the difference;—and this difference is, in a great measure, owing to the discoveries made by means of this new instrument of investigation." The improvement spoken of, consisted in substituting plates of metal, for the foil, or leaf, and wet instead of dry columns, which vastly increased its power. This pile consisted of alternate layers of circular plates of zinc and silver, or zinc and copper, with card or pasteboard between them, moistened with some saline solution. To the two extremities of this pile, being in opposite states of electricity conducting wires were attached, and when brought into contact, galvanic phenomena were produced. The greater the number of alternate layers of such a pile, the greater the electrical intensity, or, if it be desirable to construct a pile of this kind of considerable power, and it be inconvenient to form it in one pile, two may be used just as well, by connecting *the positive pole of the one, with the negative* pole of the other.

The prominent leading object which we shall have in view in our experiments and deductions from them, will be to establish, beyond the possibility of a rational doubt, the identity of the imponderables One of the illustrations, which will aid in the demonstration of that fact, is the similarity between the galvanic, and the electric spark. If I alternately break and close the circuit of the pile, as it is called, through the medium of a cup of mercury—that is, if I keep one pole constantly in the mercury, and alternately insert and remove the other, there will be an explosion of a brilliant spark consequent upon every removal which every one can perceive is precisely similar to the electric spark.

In proof of identity, there is another conclusive illustration. If I place the two poles of the pile in contact with the knob of a Leyden jar, and keep them in contact for some time, the jar will be charged the same as with an electric machine, though its intensity will be somewhat lower. This fact can be shown by discharging it with an electric discharger.

This pile will give out shocks like an electric machine. If a finger of each hand be first moistened with water or some acidulated solution, and be touched to the two poles of the pile there will be perceived a shock more or less intense, in accordance with the number of plates in the arrangement. Just such a shock will be repeated every time the person, trying the experiment, shall make and break the connection, by removing and replacing one of his fingers. But if the finger be continued in contact, without making or breaking the connection, there will be no particular sensation produced, or perceptible, unless there be, somewhere on the hand, a rupture of the skin, in which case there will be experienced a slight burning sensation.

There is another experiment, which will develope a very extraordinary and mysterious fact, respecting one of the inherent constituent properties of electricity, which we shall thoroughly investigate in this connection, and see, if it does not throw a flood of new light upon the phenomena of disease, the best methods of medical treatment in certain cases, and the hidden organic causes and laws of chemical changes—of decompositions and recompositions. The fact to which I shall allude, is this.

If a person shall touch the negative end of the voltaic pile with a moistened finger, and bring a platinum or gold wire from the positive end in contact with the tongue, a strong acid taste will be perceptible in the mouth of the experimenter. But if the wire from the negative end be brought in contact with the tongue, while the moistened finger be placed in contact with the positive pole, there will, on the contrary, be produced in the mouth a strong burning or alkaline taste. Now why is this? The answer to this question might well of itself fill a volume, for it is a key to unlock the rich casket of a thousand mysteries. It cannot, therefore, be expected that I should do more than merely glance at the solution of this wonderful phenomenon, in the space allotted for the completion of this lecture, and if, in my anxiety to do as much justice to the subject as can be done in a single lecture, I should extend my remarks somewhat beyond the ordinary bounds of one, I hope that my reader will not be offended with this burdensome tax upon his patience.

To proceed, then, why will the *positive* pole, when brought in contact with the tongue, produce an *acid* taste, and the *negative* pole an *alkaline* taste? We shall assume, in the first place, as the basis or data of our reasonings and deductions upon the subject, that it must be something *inherent* in the galvanic current itself, or in some chemical change produced in the system by the course of the passing current, or in both combined. We believe it to be in both combined.

In our investigations of common electricity, it will be recollected that we established, upon the basis of a self evident proposition or axiom, that one end of its ultimate particles is opposite entirely in its nature to the other end, since one end of a current is attractive and the other repulsive, and, as the laws of a whole are the laws of its parts, then, of course, each atom of that whole has an attractive and a repulsive power, by the opposite polarity of its opposite sides. Now then, if, as is demonstrated in the experiment just referred to, the whole current has a taste, just in accordance with the direction in which it runs across the tongue, each ultimate particle, which aids in constituting that current and its organic laws, has, also, a taste in accordance with the direction in which *it* runs, as can be proven by the same process of reasoning.

It is demonstrated, then, by experiment and by deductions built upon self evident propositions, that each of the two ends of the ultimate particles of electricity have opposite tastes—the one an alkaline and the other an acid taste.

Now how admirably this fact exhibits the uniformity of natures laws! How lucidly it proves that there is no clashing at all in the principles of her government! What a firm and immoveable basis it lays for confidence, that, when we have ascertained, beyond the possibility of doubt, one isolated fact, proving the existence of a certain definite law, other facts, when discovered, will harmonize with the evidence of the first fact, if they relate to the same subject or class of subjects, and will increase the weight of proof as to the existence of such a law, thus chaining the uniform testimony of isolated facts together into an harmonious and irresistably convincing sum total of proof, and thus giving a satisfactory and almost mathematical certainty to our knowledge!

What is the corroborating testimony of facts in the case under consideration? It is this. We demonstrated in our last lecture, by a series of deductions, based upon experiments, that the two ends of every ultimate particle of electricity have opposite polarities—that, when a body is charged *plus*, there is an emanation—*that*, in every emanation or outward current, the ultimate particles of the agent, that constitutes it, present their positive end, as that always leads—that a minus body has an *inhalation* of the electric breeze, as it were, or an inward current from surrounding substances, and is negative, because the rear end of each particle, or that which always follows the lead of the positive in all the movements of electricity, is, in its organic constitution, negative.

Now then for a forcible illustration of the admirable uniformity of those facts, which demonstrate natures laws. When a current of electricity runs *in* at the tongue, it leaves an *acid* taste, and, when *out* of the tongue, an *alkaline* taste. Now the inward current, as we have before frequently remarked, presents its *negative* end and the outward its *positive* end. In the inward current, the negative end of each particle as it passes in, gives inherent organic taste, and so with the other. Now, in what electrical states are the alkalies and the acids? Why exactly in *opposite* states. The acids are negative and the alkalies are positive. The inward current has a *negative* polarity, and is also *acid*, and the outward has a *positive* polarity and is *alkaline* The positive and negative, then, in both cases—yea in the whole three cases agree perfectly, both as to *taste* and *polarity*—the taste of the negative end of a current being acid, which acid in the form of salts is also negative, and the taste of the positive end of a current being alkaline, which alkaline, in the form of salts, is also positive.—The strong chemical affinity which exists between the alkalies and the acids is familiar to all. Tartaric acid and soda, for instance, when brought in contact with each other in solution, are attracted to each other, a powerful effervescence ensues, and a chemical union is formed between the two. Now this attraction must be entirely owing to the attraction of positive and negative electricity, or of opposite polarities, since the one is plus and the other minus, and since a foundation seems to be laid for an alkali and an acid in the organic constitution of the ultimate particles of electricity itself.

In the harmonizing facts, which the experiments develope, we, doubtless, discover the very fundamental cause of all chemical attractions or affinities, and, of course, of all chemical changes, as well as the causes of disease and the most appropriate remedies for such disease.

After having given a further description of the progress of the science of Galvanism in the construction, improvement and use of apparatus. we will then discuss in full, the several topics of the chemical decomposition of substances. the various causes and phenomena of disease in the human system, so far as they depend upon the different electrical states of that system, and the appropriate remedies for such disease and the chemical reasons why such remedies in certain cases are available.

The next invention which followed those to which we have alluded was that of the trough or galvanic battery by Mr. Cruikshanks of Woolwich, England, which succeeded the Voltaic pile, and, with improvements, is now generally used. His trough consisted of babed mahogany, about four inches wide and four deep. Into grooves cut in the sides and bottom of this trough, at small distances from each other, were inserted alternate plates of zinc and copper soldered together at the ends, and cemented into the grooves by sealing wax, or some other similar material, so as to prevent the water from passing from one cell to another. Into these insulated cells was poured either a saline or strongly acidulated solution and the extreme plates were brought into connection by means of conducting wires, called poles.

This battery was very materially improved by so constructing it, that the zinc plates could be lifted out of the cells, when not in use and thus their otherwise rapid corrosion was, in a measure, prevented.

Following this are the improvements made by Dr. Hare of Philadelphia, and which are thus described by Thomson.

"Dr. Hare, professor of chemistry at Philadelphia, has contrived a new modification of the galvanic apparatus. He takes two plates, one of copper and the other of zinc, and placing a disc of leather between the two, he rolls them up in the form of a spiral. The leather disc is now removed, and the two metals are prevented from touching each other by interposing slips of wood. Each of these plates is made to communicate with a plate of a different kind of metal, the zinc with copper, and the copper with zinc, precisely in the way already described when giving an account of the troughs. A number of these double spirals are fixed upon a piece of wood in the same way as has been just explained. These cylinders are now introduced, each into a cylindrical glass vessel. This method of construction is attended with several important advantages. By this contrivance plates of a very large size may be introduced into a small vessel: so that the expenditure of liquid is the least possible. Besides the greatest part of the two sides of each plate is active, being placed opposite to a face of the other metal.

"Dr. Hare has construced another apparatus which he calls a *deflagrator*, and which appears to possess very great power. He takes a plate of zinc three or four inches square and closes it in a case of copper, distant from it about a line, and touching it nowhere.—Any number of of these plates thus enclosed in copper is attached to a horizontal piece of wood, and fixed immoveably. that there may be no risk of the plate of zinc touching the copper case in which it is enclosed. The zinc plate at the first of these is united at the top to the copper case of the next zinc plate. And this is continued through the whole. These copper cases are placed at a very small distance from each other, and between each pair is introduced a piece of card dipped in linseed oil varnish, and half dry. They are then compressed so as to adhere so closely to each other, that no water can insinuate itself between them. Things being thus disposed, the apparatus is plunged into a trough containing the liquid, and not divided into cells; the varnished card answering all the purposes of the diaphragms in the porcelain troughs. Four such pieces of apparatus, containing each fifty plates of zinc, surrounded by its copper case, when plunged into the proper troughs, produce very powerful effects.

"The apparatus employed by Oersted, and of the efficacy of which he speaks in high terms, approaches very nearly to this last one of Hare. Indeed the theoretical construction of both is the same."

I have not time to describe the various experiments and improvements of Morichini, Professor Oersted of Copenhagen, Sir Humphrey Davy and several others. I would only remark, that it has been ascertained, that an arrangement of a very large number of small plates constitutes the kind of battery to be used in giving shocks and in chemical decompositions, and that an arrangement of a few plates, exposing a very large surface, constitutes the proper kind for evolving very great heat.

Dr. Ure, of Glasgow, in Scotland, performed, some time since, upon the body of a murderer, who had been hung, several experiments with a battery of the former kind, consisting of 270 pairs of 4 inch plates

1st. One pole of this battery was introduced into an incision in the nape of the neck, so as to come in contact with the spinal marrow, while the other was applied to what is called the sciatic nerve.—The consequence was that every muscle of the body was agitated with a convulsive quiver, as if violently shuddering from the effect of cold.

2d. By continuing one pole in the nape of the neck, as before, and removing the other to an incision made in the heel, the knee being previously bent, the leg was thrown out with such force and violence, as nearly to kick over one of the assistants, who attempted to prevent its extension.

3d. One pole was inserted in an incision made to what is called the phrenic nerve, and the other between the ribs, so as to touch the diaphragm at the bottom of the lungs. The consequence was that the chest rose and fell as in heavy natural breathing.

4th. One pole was brought in contact with the supra-orbital nerve in the forehead and the other with the heel, when every muscle of the countenance was simultaneously thrown into fearful action. Rage, horror, despair and ghastly smiles united their hideous expression in the murderers countenance. So horrid was the sight, that several spectators were forced to leave the room in which the experiments were made, either from terror or sickness, and one gentleman fainted.

5th. One pole was inserted again in the nape of the neck, and the other brought in contact with the ulner nerve at the elbow. Immediately the fingers moved nimbly like those of a violin performer.—An assistant tried to close the hand, but found it would open forcibly, in spite of his efforts. When the rod was removed from the elbow to a slight incision in the forefinger, the fist being previously clenched, that finger instantly extended and, by the convulsive agitation of the arm, the murderer seemed to point to the different spectators, some of whom thought the had come to life.

With the foregoing series of interesting experiments, we shall bring to a conclusion the present lecture, and defer the further consideration of Galvanism to the next, requesting the reader, however, before we dismiss the subject, to keep in recollection those experiments in particular, as we think they will throw some light upon the subject, when we come to consider the agency of the electric principle in the various departments of organic life, and the abstruse science of Pathology.

LECTURE V.

SUBJECT—GALVANISM.

Before commencing a discussion upon the subject of the chemical changes produced by the imponderable principle in ponderable matter, whether organic or inorganic, we will give a description of one or two other important pieces of galvanic apparatus now in use.

Dr. Hare's Calorimotor, as it is called, is a battery of the other kind, which evolves great heat, and yet produces but a slight electric effect upon the muscular system, and in the chemical decomposition of substances. He constructed it of several 18 inch plates, and had it so arranged, that all the plates of copper were joined together by a band of metal, and those of zinc in the same way. By this arrangement, all the plates became, in fact, but one pair, having an immense surface exposed to the galvanic action.

Mr. Children of England, in 1814, constructed one of this kind, consisting of 20 pairs of zinc and copper plates, each 6 feet long and 2 feet 6 inches broad, joined together with straps of lead. By immersing this battery in a mixture of nitric and sulphuric acids with from 20 to 40 times their weight of water, the following experiments were made. A platinum wire five feet six inches long and 11-100 of an inch in diameter was made red hot throughout, so that the ignition was visible in full day light. Eight feet and six inches of platinum wire 44-100 of an inch in diameter were heated red. A bar of platinum 1-6 of an inch square and two inches and a quarter long was heated red hot and melted at the end. A round bar of the same metal 276-1000 of an inch in diameter and two and a quarter inches long, was heated bright red throughout.

Before passing to other topics, it may be appropriate, in connection with the subject of galvanic batteries, to remark upon the different solutions used in experimenting and their various effects. This we will do in the language of Thomson, page 517.

"The energy of the galvanic battery depends very much upon the nature of the liquid employed as a conductor between the pairs of plates. The better conductor of electricity it is, the more powerful, *ceteris paribus*, is the energy of the battery. When we employ pure water the energy is a minimum. Indeed it seems doubtful whether the pile possesses any activity when the water used is perfectly pure, and perfectly freed from atmospherical air. Water containing a salt in solution, answers much better, because the addition of a salt increases very much the conducting power of water. Common salt, sulphate of soda, alum, nitre, or sal ammoniac, are often employed. The more easily the salt is decomposed the better does it answer. Acids on that account answer better than salts. The three acids usually employed are the sulphuric, muriatic, and nitric. Of these the muriatic acid has the least energy ; the sulphuric comes next in order : but the nitric acid is the most efficacious of all.

The stronger the saline or acid solution is, the more powerful is the action of the battery. The action of nitric acid is the most energetic ; but it ceases most speedily. The experiments of Gay Lussac and Thenard have shown that the addition of 10, 20, 30, &c., parts of concentrated nitric acid to a given weight of water increases the intensity of the battery 10, 20, 30, &c. times, or that the energy is directly proportional to the strength of the acid employed. The charge usually employed in this country is a mixture of 1 part of concentrated acid with about 20 or 25 parts of water.

" The action of the sulphuric acid lasts longer than that of the nitric, and that of the muriatic is more lasting than that of the sulphuric. The addition of some sulphuric acid to the nitric acid solution (as was the practice of Sir H Davy) renders the action much longer —because the sulphuric acid prevents the nitric acid from being saturated by the oxide of zinc formed. The energy, of course, continues till the whole nitric acid is decomposed.

"Of the salts, sal ammoniac is the most powerful. A solution of common salt in vinegar acts well, and is most commonly used by experimenters, as the cheapest ingredient likely to answer the purpose.

" Having given a sufficient account of the galvanic apparatus, it is time to turn our attentien to the effects which it produces."

In a former lecture of the course, we assumed, it will be recollected that there were but *three* essential principles in creation—viz: *ponderable matter*, *imponderable matter* and mind, and that all the chemical changes, within the whole wide range of philosophic investigation, were produced by the energizing influence of the imponderable principle over ponderable matter. This, we are aware, is stating a proposition, somewhat new, in strong and decided terms —is taking a position, which has uot been definitely taken by any standard authors upon the subject, although they have published many things and facts, which will be of very essential service, in aiding to establish fully, what we are attempting to demonstrate—and, as many may, very probably, be disposed to regard the position as wholly untenable, we shall first quote largely from Thomson, to show what has been ascertained by experiment, as he seems to have taken much pains to collocate and condense the recorded results of the labors of learned and practical chemists.

Our first examinations will be confined to inorganic substances, and, as we quote the opinions of others, we shall regard them merely *as* opinions, disconnected entirely from the facts recorded, which opinions we shall not regard as resting upon an infallible basis of reasoning, nor shall we endorse their conclusions as resulting necessarily from the facts in the case, except where it shall appear perfectly conclusive that they do.

We shall also premise another thing before proceding to make those quotations. They may not be arranged exactly in that methodical order and concise form, which would strictly comport with a work, designed to be so condensed as this.

We will first quote what Thompson says, between pages 491 and 495, under the head "*of Electricity by Contact.*"

"A considerable number of experiments on electricity by contact was made by Sir H. Davy. When oxalic, succinic, benzoic, or boracic acid, perfectly dry, either in powder or in crystals, are touched upon an extended surface with a plate of copper insulated by a glass handle, the *copper* becomes *positive*, and the *acids negative*.—When zinc or tin is substituted for copper the effect is the same.—Phosphoric acid perfectly dry, when applied to copper becomes negative, and the copper positive. When metallic plates are made to touch dry lime, strontian, barytes, or magnesia, these alkaline bodies become *positive*, the metal negative. With soda the effect is the same. Potash attracts moisture so rapidly that the experiment cannot be tried with it. When sulphur is applied to polished lead, or to any other metal, it becomes positive.*

"It has been ascertained that electricity, when employed in the way described heretofore, and known by the name of the Voltaic battery, is capable of decomposing all compound bodies, and the decomposition takes place according to a particular law. When two platinum wires attached to the two poles of the battery are plunged into a vessel of water, the water is reduced into its elements, and the *oxygen* is always extricated from the wire attached to the *positive* pole, while the hydrogen rises from the wire attached to the *negative* pole. When the wires are plunged into a strong solution of muria-

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tic acid, the chlorine is accumulated round the positive wire, and the hydrogen round the negative. The law according to which *hydrobromic* and *hydriodic* acids are decomposed is the same. The bromine and iodine are attracted to the positive pole, while the hydrogen is attracted to the negative pole. When chloride of sodium or potassium is decomposed, the chlorine passes to the positive pole, while the sodium and potassium pass to the negative pole. Were a compound of sulphur with oxygen to be decomposed, the oxygen would attach itself to the positive pole. But with sulphuret of zinc or of iron the case would be different. The sulphur would collect round the positive pole, and the metal round the negative pole.— When salts are decomposed, the acid is attracted to the positive pole, and the base to the negative.

"Now as bodies are attracted by those in a different state of excitement from themselves, it follows that oxygen, chlorine, bromine, and iodine, and acids, would not be attracted to the positive pole, unless they themselves were in a negative state; nor would hydrogen and bases be attracted to the negative pole unless they were in a positive state. From this it has been concluded that bodies which have an attraction for each other are in opposite states of electricity, and that it is to these opposite states that their attraction for each other, and their union with each other, is owing. The current of electricity destroys their union by bringing them into the same electrical state. In consequence of this view, which is at least exceedingly ingenious and plausible. bodies have been divided into two sets, those which are negative, and those which are positive. The following table exhibits a list of the negative bodies beginning with those which possess the negative property in the highest degree, and terminating with those in which it is lowest.

Oxygen,
Chlorine,

Molybdenum,
Chromium,

Bromine,
Iodine,
Sulphur,
Phosphorus,
Selenium,
Arsenic,
Titanium,
Tungsten,
Boron,
Carbon,
Antimony,
Tellurium,
Columbium,
Silicon.

lowing table exhibits a list of the positive bodies begi
he one in which the property is weakest, and ending wit
which it is strongest.

Gold.
Platinum,
Palladium,
Osmium?
Iridium,
Rhodium,
Mercury,
Silver,
Copper,
Nickel,
Cobalt,
Bismuth,
Tin,
Zirconium,
Lead,
Cerium,
Uranium,
Iron,
Cadmium,
Zinc,
Manganese,
Aluminum,
Thorinum,
Yttrium,
Glucinum,
Magnesium,
Calcium,
Strontium,
Barium,
Lithium,
Sodium,
Potassium.

it easy to decide where hydrogen should be placed. Com-
oxygen it is strongly positive. But it combines with the
and must with respect to it be negative. The bodies
e head of the first list being most powerfully nega-
he greatest chemical affinity for each other. Bodies in
ist have but little affinity for each other, those towards the

bottom of the first list have but little affinity with those towards the top of the second list. However the bodies in the same list are not destitute of affinity for each other. Thus sulphur combines readily with arsenic. Because these two bodies assume different states with respect to each other. When we decompose sulphuret of arsenic, the sulphur is attracted to the positive pole, and the arsenic to the negative; showing that the former is in a negative state, and the latter in a positive. It is for this reason that almost all the substances constituting the first list, are capable of uniting with each other as well as with those of the second. Now it deserves attention, that when the bodies constituting the first list unite with each other, they constitute *acids* or substances which act the part of acids; when they combine with the substances constituting the second list, they constitute *bases* or substances which act the part of bases. All the acids are combinations of the negative bodies with each other, all the bases are compounds of the negative bodies with the positive. I have left out azote because it is not easy to say where it ought to stand; but it belongs undoubtedly to the class of negative bodies, and should stand probably before *sulphur*.

Hydrogen I have purposely omitted. It constitutes *acids* by combining with the greater number of the negative bodies; but we are ignorant at present of any compound which it forms with any of the positive bodies, excepting with potassium, which, according to the experiments of Gay-Lussac and Thenard, absorbs hydrogen gas and forms a compound. But this combination has not succeeded in the hands of other experimenters."

"Ever since the discovery of the identity of lightning and electricity, the attention of electricians has been turned to the accumulation of electricity in the atmosphere. And various causes for such an accumulation have been assigned. The opinion of Volta has been most commonly adopted. According to him whenever a body changes its state, it becomes electric. Now water is continually ascending into the atmosphere in the state of vapour, or falling from it in the state of rain. By these continual changes of state, which this fluid undergoes, Volta supposed that the accumulation of electricity in the atmosphere was chiefly produced. This opinion was verified by Lavoisier and Laplace. But when Saussure repeated the experiments, he was unable to obtain any satisfactory results. M. Pouillet has recently examined the subject with much care, and has found that no sensible quantity of electricity is evolved when water changes its state, unless at the same time some chemical action more or less vigorous accompanies the change. But whenever two gaseous bodies unite with each other, or a gaseous body with a solid body, one of the uniting bodies always gives out positive electricity, and the other negative electricity.* These experiments being of great importance, both for understanding the sources of atmospherical electricity, and for determining the kind of electricity possessed by those bodies, which have a chemical affinity for each other, it will be worth while to state them somewhat particularly. When charcoal is burnt it sometimes gives out positive, and sometimes negative electricity, and sometimes no electricity at all. This depends upon the way in which the combustion is conducted. To obtain constant results, M. Pouillet proceeded, in the following manner. He took a piece of charcoal of such a diameter that it could receive the form of a cylinder whose bases were nearly plain. This piece of charcoal was placed vertically, two inches and a half, or three inches below a plate of brass which rests upon one of the discs of the condenser. The charcoal communicated with the ground, and was lighted at its superior base, taking care that the fire did not reach the lateral surface. A current of carbonic acid rises and strikes against the plate, and in a few minutes the condenser is charged. The electricity which it receives from the carbonic acid gas is always *positive*. If the plane be allowed to communicate to the sides of the charcoal, or if it be inclined so that the carbonic acid formed must slide up along the base of the charcoal, no sensible effect is obtained.

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*Ann. de Chim. et de Phys, xxxv. 401

"To obtain the electricity which the charcoal itself takes by combustion, M. Pouillet placed its inferior end directly upon the disc of the condenser, and then lighted its superior base. In a few minutes the condenser was charged with negative electricity. From these experiments, we learn that when charcoal is burnt, it becomes charged with negative electricity, while the carbonic acid evolved is charged with positive electricity. Now the combustion of charcoal is the combination of it with oxygen, so as to constitute carbonic acid. According to Pouillet, during this combination, the oxygen gives out positive electricity, which is found in the carbonic acid gas, while the charcoal gives out negative electricity, which is found in the portion of the charcoal not yet burned. Now when the carbonic acid gas is again decomposed into its elements, the oxygen takes back positive electricity, and the carbon negative electricity. Is not this the reason, why the oxygen gas is attracted towards the positive pole of the Voltaic battery, while the carbon is attracted to the negative pole ?

"The flame of hydrogen gave contradictory results with respect to its electricity, as had been the case also at first with charcoal. In the course of a few minutes it gave indications both of positive and negative electricity; very intense and very weak indications, and often it was impossible to obtain any indication at all. But these difficulties were at length overcome by M. Pouillet in the following manner.

"The hydrogen gas was made to flow out of a glass tube. The flame was vertical, having a breadth of 4 or 5 lines, and a height of about three inches. A coil of platinum wire was employed to conduct the electricity from the flame to the condenser. When this coil was so much larger than the flame as to enclose it, and to be distant from its external surface about 4 inches, signs of positive electricity made their appearance. These signs became more and more intense as the distance diminished. But when the coil became so small as to touch the flame, the electrical signs became weak and uncertain. Thus it appears that round the flame of hydrogen, there is a sort of atmosphere at least 4 inches in thickness, which is always charged with positive electricity.

" If a very small coil of platinum wire be placed in the centre of the flame, in such a manner, that it is enveloped on all sides; and made to communicate with the condenser, that instrument becomes immediately charged with negative electricity. Thus it appears that the outside of the flame of hydrogen gas is always charged with positive electricity, and the inside with negative electricity. It follows from this, that there is a layer of the flame where the electricity is invisible. Accordingly if we regulate the coil in such a manner that it *penetrates nearly one-half into the* bright part of the flame, all electrical indications disappear.

From these experiments, it appears that the electricity evolved during the combustion of hydrogen. is quite similar to what appears during the combustion of charcoal. The oxygen before it enters into combination is charged with positive, and the hydrogen with negative electricity. Oxygen then must part with positive electricity when it combines with hydrogen, and hydrogen must part with negative electricity when it combines with oxygen.

" If instead of making the hydrogen gas flow out of a glass tube, we make it flow out by a tube of metal, which does not communicate with the ground, but only with the condenser, this metal tube which touches the hydrogen, but not the flame, always becomes charged with negative electricity. But if it communicate with the ground it loses the negative electricity, which it had lately carried to the condenser, and the product of the combustion preserves an excess of positive electricity.

" If we examine at a height of a few inches above the vertical flame, we find both the electricities in the same quantity and not recomposed. For if we present a soldered plate of zinc and copper, the zinc plate attracts the negative, and the copper plate the positive electricity. When we go to a distance sufficiently great above the vertical flame, the electrical fluids can no longer be recognised, because they have combined and neutralized each other.

Pouillet examined the flames of alcohol, ether, wax, oils, fat, many and vegetable bodies which presented the same phenomena as that of hydrogen. That is to say, that a zone of air surroumding the flame was electrified plus, while the interior of the flame was electrified minus. All these combustions exhibit examples of oxygen uniting with hydrogen and carbon. The oxygen gives out positive electricity, while the combustible body, whether hydrogen or carbon, or a compound of the two, gives out negative electricity.

"It has been ascertained by the experiments of Priestly, Ingenhousz, Sennebier, Saussure, &c. that plants while vegetating act upon atmospherical air; sometimes forming a great quantity of carbonic acid, which disengages itself insensibly. and sometimes on the other hand gives out oxygen gas in a state of greater or less purity. Now it appears from the preceding experiments, that when carbonic acid is formed by combustion, it is electrified plus. This led M. Pouillet to suspect that the carbonic acid given out during the processes of vegetation, would be in the same predicament To determine this point, he made the following experiment.

"Twelve glass capsules, about 8 inches in diameter, were coated externally for two inches round the lips with a film of lac varnish.—They were arranged in two rows beside each other, either by placing them simply on a table of very dry wood, or by putting them on a table previously varnished by gum lac. They were filled with vegetable mould, and were made to communicate with each other by metallic wires which passed from the inside of the one to the outside of the other, going over the edges of the capsules. Thus the insides of the

12 capsules, and the soil which they contained, formed only a single conducting body. One of these capsules was placed in communication with the upper plate of a condenser by means of a brass wire; while at the same time the under plate was in communication with the ground. Things being in this situation, and the weather very dry, a quantity of corn was sown in the soil contained in the capsules and the effects were watched. The laboratory was carefully shut, and neither fire, nor light, nor any electrified bodies, were introduced into it.

"During the two first days the grains swelled, and the plumula issued out about the length of a line, but did not yet make its appearance above the surface of the earth. But on the third day the blade appeared above the surface, and began to incline to the window which was not provided with shutters. Consequently the carbonic acid gas, which *disengages itself during the germination* of seeds, is charged with positive electricity, and *is therefore precisely* in the same state as the carbonic acid gas formed by combustion. This experiment was several times repeated with success. But the electricity cannot be recognised unless the weather be exceedingly dry, or unless we dry the apartment artificially by introducing substances which have the property of absorbing moisture.

"These capsules being insulated, and the air being very dry, and the soil so dry that it is an imperfect conductor, it is evident that the electricity would be retained. Accordingly when the condenser was brought into a natural state after one observation, and if it was then replaced for experiment only during one second, it was found to be charged with electricity.

"It is obvious enough that the gaseous fluids given out by plants during the process of vegetation, being charged with electricity, must contribute to furnish no inconsiderable portion of the electricity with which the atmosphere becomes loaded. No doubt the carbonic acid gas evolved from animals by respiration is also charged with positive electricity; though it would be somewhat difficult to determine the point by actually charging a condenser, in consequence of the moisture with which the expired air is always loaded.*"

Other important agencies of Galvanism are described by Thomson, commencing on the 529th page of his work on "Heat and Electricity," which we shall quote in full, before proceeding to comment upon them, and to make them the data of certain deductions, which have a bearing upon the settlement of the question at issue.

"The chemical effects of the Voltaic battery have been investigated with much sagacity, and have thrown a flood of light upon the nature of chemical combination. Every substance constituting the liquid conductor interposed between the pairs of plates undergoes decomposition, one of its constituents being attracted to the positive plate, and the other to the negative. Suppose the liquid conductor to be *water*. The *ogygen* is attracted to the positive or zinc plate, which it converts into an oxide, while the other constituent, the *hydrogen*, is attracted to the negative or copper plate. Hydrogen does not combine with copper. It therefore makes its escape from the face of the copper plate in the form of hydrogen gas. When pure water is used, the decomposition is exceedingly slow, because pure water conducts electricity of low intensity very badly. If we add nitric acid to the water, the energy of the battery is very much increased, because the conducting power of the liquid is greatly augmented. and because the nitric acid undergoes decomposition much more easily than water. In this case both of the constituents of the liquid conductor undergo decomposition ; the water is reduced into its elements as before, and the oxygen, as before, unites to the zinc plate, while the hydrogen is disengaged from the copper plate' The nitric acid is decomposed into oxygen and deutoxide of azote.

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* The reader may consult with advantage an elaborate and most ingenious set of experiments by Sir H. Davy, to establish his own views, which are inconsistent with those of Pouillet, in Phil. Trans. 1826, p. 398.

The oxygen unites to the zinc, while the deutoxide of azote is disengaged in abundance from the copper plate If the nitric acid solution used possess considerable strength, a good deal of heat is evolved, and the quantity of deutoxide of azote and hydrogen given out is very annoying to the experimenter. The zinc is oxidized and dissolved very fast, and the energy of the battery is soon destroyed. Because, in a very short time the whole nitric acid is either decomposed, or combined with the oxide of zinc. The liquid becomes a solution of nitrate of zinc in water, which is comparatively speaking a bad conductor of electricity.

"It would appear, that while the energy of the Voltaic battery continues, two opposite currents of electricity pass through every stratum of liquid, interposed between every pair of plates. The negative electricity passes towards the copper plate, and the positive electricity towards the zinc plate. To form a conception of the way in which these currents pass, let us consider the conducting liquid in its simplest state, or consisting of water. Water is a compound of oxygen and hydrogen. Let us consider only a single row of the particles of it, lying between the zinc and copper plate.—Let fig. 1, represent oxygen, and fig. 2, hydrogen. A particle of water may be represented by the symbol $\frac{1}{2}$. and a row of particles of water may be represented thus:

$$\frac{1}{2}\ \frac{1}{2}\ \frac{1}{2}\ \frac{1}{2}\ \frac{1}{2}\ \frac{1}{2}\ \frac{1}{2}\ \frac{1}{2}\ \frac{1}{2}\ \frac{1}{2}\ \frac{1}{2}\ \frac{1}{2}$$

The current of negative electricity seems to pass along the particles of oxygen, and the current of positive electricity along the particles of hydrogen. From M. Pouillet's experiments related in the last section, it would follow that when oxygen and hydrogen combine the former gives out positive, and the latter negative electricity.—We may conclude from this, that when they become charged again with these respective electricities, they will separate from each other. The particle of oxygen next the zinc plate, being thus disengaged from particles of hydrogen with which it was united, will be attracted to the zinc plate, give out its electricity to it, and combine with it. The same thing will happen to the particle of hydrogen nearest the copper plate. The electricity constantly passing along the row of particles, will occasion a succession of decompositions of the particles of water. But the hydrogen in each, will instantly combine again with the next particle of oxygen in succession. It is not then the hydrogen which passes through the liquid from one plate to the other, but a rapid succession of decompositions; and as the first particle of water has parted with its oxygen, it is obvious that the last particle must part with its hydrogen.

"The same explanation applies to all the decompositions that take place, in the liquid interposed between the respective pairs of zinc and copper plates. But it is usual to interpose between the two poles of the Voltaic battery, a vessel containing the water or other substance to be decomposed. A platinum wire is made to pass into this liquid from each pole, and the series of decompositions may thus be observed.

"The nature of these decompositions was first investigated by Berzelius and Hisinger, in a paper published by them, in Gehlen's Journal for 1802.* They showed that a number of salts which they dissolved in water, and placed in contact with the two poles of a galvanic pile, by means of iron or silver wires, were decomposed, the acid being deposited round the positive wires, and the base round the negative pole.† Ammonia was also decomposed; azotic gas separating from the positive pole of the battery, and hydrogen gas from the negative pole. When lime water was tried, no decomposition of the lime took place.

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[*] Vol. i. p. 115.

[†] The salts tried, were—
Sulphate of ammonia,
Nitrate of ammonia,
Muriate of ammonia,
Phosphate of ammonia,
Borate of ammonia,
Prussiate of ammonia,
Common salt,
Nitrate of potash,
Bisulphate of potash,
Sulphate of potash,
Muriate of lime.

In the Philosophical Transactions for 1807 an admirable paper was published by Sir Humphrey Davy entitled "*On some Chemical Agencies of Electricity*," containing a very minute and complete investigation of the chemical decompositions produced by Voltaic electricity. To perceive the full value of this paper, it would be requisite to [illegible] of the previous state of our knowledge of this intricate subject. It had been already observed, that when two platinum wires attached to the two poles of a galvanic pile were plunged each into a vessel of water, and the two vessels united by means of wet asbestus or any other conducting substance, an acid appeared round the positive wire and an alkali round the negative wire.

This alkali was said by some to be ammonia, by others to be soda. The acid was variously stated as muriatic acid, nitric acid, or even chlorine. And it was generally admitted, that these acids and alkalies were generated by the galvanic action. Sir H. Davy demonstrated, by decisive experiments, that in these cases the acid and alkali were derived from the decomposition of some salt contained either in the water or in the vessel in which the water was placed. Most commonly the salt decomposed was common salt, and he showed that agate, basalt, and various other stony bodies, when he used as vessels, contained quantities of common salt appreciable by the galvanic action. When the same agate cup was used in successive experiments, the quantity of acid and alkali evolved diminished each time, and at last no appreciable quantity could be perceived. When glass vessels were used, soda was disengaged at the expense of the glass, which was sensibly corroded. When the water into which the wires were dipt was perfectly pure, and when the vessel containing it was free from every trace of saline matter, no acid or alkali made its appearance, and nothing was evolved except the two constituents of water, namely oxygen and hydrogen; the oxygen appearing round the positive wire, and hydrogen round the negative wire.

When a salt was put into a vessel into which the positive wire dipt, the vessel into which the negative wire dipt being filled with pure water, and the two vessels being united by a slip of asbestus moistened with water, the acid of the salt made its appearance round the positive wire, and the alkali round the negative wire, before it could be detected in the intermediate space. But if an intermediate vessel containing a substance for which the alkali has a strong affinity, be placed between these two vessels, the whole being united by slips of asbestus, then a great part of, or even the whole of the alkali, was nitrate of barytes, and sulphuric acid was placed in the intermediate vessel; much sulphate of barytes was deposited in the intermediate vessel, and very little or even no barytes made its appearance round the negative wire. Upon this subject a most minute, extensive, and satisfactory series of experiments was made by Davy, having no doubt whatever respecting the accuracy of the general fact. Indeed this paper of Sir H. Davy constitutes one of the most important contributions, ever made to scientific chemistry, and threw a ray of light upon the chemical affinity, which may ultimately produce the most important consequences.

" The conclusions drawn by Davy from his experiments, are that all substances which have a chemical affinity for each other, are in opposite states of electricity, and that the degree of affinity is proportional to the intensity of these opposite states. When such a compound body is placed in contact with the two poles of a galvanic battery, the positive pole attracts that constituent which is negative, and repels the positive. The negative pole acts in the opposite way, attracting the positive constituent, and repelling the negative. The more powerful the battery, the greater is the force of these attractions and repulsions. We may, therefore, merely by increasing the energy of the battery, sufficiently, enable it to decompose any compound whatever. Oxygen, chlorine, bromine, iodine, and acids, being negative bodies, are attracted to the positive pole; while hydrogen, alkalies, earths, oxides, metals, and bases of all kinds, being positive, are attracted to the negative pole.*

Such are the electrical and such the chemical phenomena produced by the Voltaic battery."

This lecture has been extended beyond due bounds, because we wished to present the interesting quotations we have made, in one view, and without division. To the next we shall defer their rigid examination. They are in part correct and partly false, as we shall endeavor to show in the next, and shall make those facts, about which there can be no mistake, subservient to the purposes for which these lectures are published.

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* If this view of the subject, which is probably more conformable to truth, than the view of Pouillet given in page 497 of this work, be admitted, it will be necessary to modify the explanation of the way in which the electrical currents pass, given in page 531. If oxygen be negative, and hydrogen positive, it is obvious that the positive current will be attracted to the oxygen and must pass through the hydrogen. These currents by neutralizing the electricity in both bodies, will occasion the separation of the oxygen and hydrogen, and produce the decompositions referred to, in page 531.

LECTURE VI.

Subject—Galvanism—The changes in organic & inorganic Matter.

The present lecture will be devoted to the application of those facts and principles of galvanism, which have been ascertained by our own observations, and those of others, to the further demonstration of the peculiarities of the theory we have assumed.

Upon the subject of the intimate connection which exists between electricity and the chemical changes, which are wrought in various substances, we quoted largely, in our former lecture—not because we could not have given those ideas in our own language, and thus have appeared to have written original thoughts—but because we wished to insert the *facts* collocated by an author, so eminent as Thomson, the "*Regius Professor of Chemistry in the University of Glasgow,*" Scotland, in his own language, so that, for minds, that demand the authority of great names, we might have a convenient reference in the body of this work, reserving to ourself, however, at the same time, the privilege which we shall ever claim and exercise, of drawing our own conclusions from those facts furnished, as the data of our reasonings.

The visible and probably invisible universe is nothing more nor less, than one vast laboratory, in which chemical changes are continually progressing in an infinite variety of forms, and modifications. The green mantle of vegetation, which clothes the earth in its beautiful summer vestments, receives its freshness, color, nourishment and increase from the air and the alimentary substances the soil at its root, by means of a chemical change. The tree of th forest, first germinates, next becomes a little delicate twig, further on in its progress we find it a pliant sapling, then it shoots upward with luxuriant, spreading branches, and downward with a firmer and deeper root, and becomes, at length, a stately monarch of the woodland, stubborn and unyielding to the wintry blast. All this progression is effected solely by a chemical change, which transforms the nutriment of the air and soil into wood. Even the solid rock has its infancy, its manhood and its old age. It begins to grow, increases in solidification and cohesive power, comes to maturity, decays and crumbles again to a substance,possessing no power of cohesive attraction at all. All this too, is effected by the potent agency of a continued chemical change. Even a pearly drop of water, embedded in the deep bosom *of the mountains, may harden by* chemical agencies, and, *in process of time, perhaps, form the sparkling* diamond.

Now we assume that it is a proposition capable of rational, abundant and satisfactory proof, that every one of these chemical changes is wrought by the resistless influences of electricity, or the light and caloric of the sun, as it falls upon, and prevades the whole material of the earth, for this light and caloric of the sun is the same thing, in fact, as electricity, which we hope abundantly to demonstrate in its proper place.

That reasoning or superstructure of argumentation, which is built upon the immovable basis of self evident propositions, cannot be overthrown by counter argumentation. It is perfectly impregnable. It is founded in the inherent nature and fitness of things, which change not, while all else in creation changes.

Upon just such propositions we intend to build the superstructure of our argument, in proof of the assumed position, that all the hemical changes are wrought by the direct agency of electricity.

The laws which govern nature are uniform. There is no clashing among them. Were there any, the universe of material systems would exhibit one terrific scene of uproar, confusion, anarchy and chaos. The proposition that "*like causes produce like effects*" is self-evident. It cannot be made any plainer to a sane mind by any process of reasoning.

We will now condense into as brief a space as is consistent with a lucid perspicuity the substance of the quotations of the last lecture, correct what is erroneous, and then make such deductions and draw such conclusions as the undeniable facts in the case will warrant.— This is the substance.

Bodies in opposite *chemical* states—that is—bodies which have a strong affinity for each other, are in opposite *electrical* states—the elements of all bodies or substances, which can be decomposed by electricity are either positive or negative—evaporation does not evolve electricity—it is, however, produced by the combustion of charcoal hydrogen gas and other bodies, and also by vegetation.

The constituent principles of bodies go to the different poles of a galvanic battery, and, by the influence of the electric agent, water is separated into its elements of oxygen and hydrogen gas, the first of which is negative and the last is positive.

This is the substance, in brief, of those quotations. With the first fact, which they develope, we agree perfectly. The acids are all *negative* and the alkalies are all *positive*. When brought in contact in the form of solution, a chemical union takes place, by the force of the affinity or the chemical attraction, which exists between the two substances. That affinity or chemical attraction, which brings the two bodies together, and effects their union into a new compound, depends entirely upon the different ingredients, which compose that new compound. The alkali is plus or positive, because, as we have before shown, it is surcharged with more than a natural share of electricity. That electricity is arranged therefore with the positive polarity of its ultimate particles outward, as in all surcharged bodies, which emanation outward, as we have demonstrated by the test of infallible experiment, constitutes it an alkali, and gives it an alkaline taste. The acid is minus or negative, owing to its destitution of electricity, which destitution gives, as we have elsewhere abundantly shown, a different arrangement to the ultimate particles of the electric agent, by which arrangement, as in all minus or negative bodies, the negative polarity is presented, which constitutes any substance an acid or gives it its acid taste. Let no one suppose that *this is a mere fanciful hypothesis*; for we have already demonstrated, that it depends upon an *inherent organic law* of electricity, by an experiment with the galvanic battery, by which it is shown, that if a current be *in* at the tongue and *out* of the finger, where one pole is brought in contact with the one, and the other with the other, it has an *acid taste, and if in at the finger and out of the* tongue, a strong alkaline taste, proving beyond *contradiction, that an acid* and an alkaline taste depend upon the electrical condition, instead of the condition of inert matter merely, without regard to its electrical state.

This suggests the thought, which philosophers would do well to investigate, whether all tastes, and every shade of taste in ponderable substances, do not depend upon the different modification, or rather the different proportions of the admixture of these two fundamental and essential tastes, rather than upon any inherent organic quality in mere inert matter itself. Reasoning from the admirable uniformity of natures laws, but without having time, in connection with this work, to demonstrate it, we should draw the confident conclusion that it did. If electricity constitutes an alkaline and an acid taste, why not, with the same propriety, the sweet, the bitter and every other possible shade of taste simply by the different electric states of bodies? That it does, we believe could be demonstrated by deductions based upon the self-evident proposition, "that like causes produce like effects."

There cannot be any mistake about the electric states of the alkalies and the acids. The testimony of experiment is uniform. The one is always plus and the other minus, and the degrees of their plus and minus depend upon their concentration. Being plus and minus they unite when brought together. That union exhibits force and is attended with the violent commotion of a rapid effervescnce, as is familiar to all in the union of tataric acid and soda. Now what is that principle of affinity which causes the tartaric acid and soda to unite? Is it any thing inherent in the mere particles of inert matter themselves, which constitute, the soda and tartaric acid? We think not. Upon conclusions drawn legitimately from all analogy we predicate this opinion. Let us examine mere ponderable matter as critically and minutely as we may, and the conviction will be forcibly impressed upon the mind, that it has no such inherent energy—no such self-moving power, as to produce a commotion among the ultimate particles of which it is composed so violent as that which occurs, when they unite with each other during effervescence. What then is that principle of affinity which brings them together, if it be not some inherent power belonging to the particles themselves? It is, without doubt, electricity, for it seems to have a sort of mysterious, indefinable, but yet positive ability to take hold of the particles of ponderable matter, as it were with a tenacious grasp, and, by its own unaided energy, control their movements. We see not how else they are brought into union. But if this be the controling agent, which effects the work, then the process by which the union is accomplished is perfectly plain. There is no incomprehensibility about it, except what exists in the essential nature and qualities of the wonderous agent itself. The one substance is surcharged, because positive, and the other deficient, because negative. There is then, upon principles, which have been already abundantly explained, an attraction between the opposite polarities of the electric principle, by which a plus and a minus are drawn together. Having, as we have before remarked, a hold, by some mysterious organic law of its essential constitution, beyond the ken of chemical analysis or investigation, upon the particles of ponderable matter, they are attracted along with it, and are thus brought, as we have seen, into a chemical union, and a chemical change is produced. This chemical union and change is nothing more nor less than the simple equalization of a plus and a minus in substances, and by that equalization, a single compound substance is formed, very different in the properties of its combination from either of the two out of which it was formed. And why? Simply because it is in a different electrical state. This simple compound, we say is very different from the two out of which it was formed, in all the properties of its combination, for this is abundantly proven by the fact that a virulent poison may be made harmless by a chemical union, and harmless substances be also made virulent poisons by the same chemical union or chemical changes. This is done, in all cases, by simply changing their electrical state, which state can be varied by an almost infinite variety of shades and modifications, constituting color, tastes, motion, poisons, antidotes against poisons, and every other property and quality, which is manifested in matter, except its bulk, ponderosity and inherent inertness.

Upon deductions built upon fact and experiment, we believe this to be the *true theory* of *all* chemical changes in matter. Those changes are effected through the sole ageny of electricity. The "*modus operandi*" of such changes may, it is true, be, in a measure, hidden sometimes from the inspection of the most acute, and may not, in a vast multitude of instances, be perfectly apparent; but still abstruseness does not at all affect the reality of that agency. If it can be proven beyond controversy and beyond the shadow of a reasonable doubt, as it certainly can, that such changes, have been effected by such agencies, then it is logical to draw an inference, from that self-evident proposition, that "like causes produce like effects," that *other* changes, whose cause is more obscure from certain circumstances that may surround them, are produced by the same agencies, in accordance with the same laws.

In the quotations, which we have made in a former lecture, it will be recollected that Sir Humphrey Davy drew the conclusion, from a great variety of experiments, conducted with the utmost care, that *all* substances, which have a chemical affinity for each other, are uniformly in opposite states of electricity, and that the *degree* of affinity is exactly proportional to the *intensity* of those opposite states.— Now, if *all* substances, according to the test of Sir Humphrey Davy's experiments, which have a chemical affinity, are in opposite electrical states, is not the union, which is effected by means of that affinity, effected simply, as we have shown, by the attractions of a positive and negative, since the laws of nature are uniform, and since "like causes produce like effects?" Or, in other words, that that chemical affinity, which exists between all substances, which will unite, is nothing more nor less than electrical attraction.

There are two ways in which mathematicians prove the truth of their calculations to a demonstrative certainty. The one is by a direct and the other is by an inverse process of deduction. In the first, by a certain process of calculation or reasoning they arrive at a certain result, and, in the other, by taking that result for their premises, and, by reasoning or calculating backward, they determine whether that process of deduction, by which they arrive at that result, is, every step of it, correct. By just such a plan of procedure, we can determine the correctness of our previous chain of argument, respecting the phenomena of chemical union. We have, by a process of direct reasoning from cause to effect, come to certain conclusions. We will now, by an inverse process of argumentation from effect to cause, prove whether there be any flaws or broken links in that chain. We have demonstrated, by an allusion to facts with which all are perfectly familiar, that the alkalies and the acids will unite by the influence of chemical attraction or of electrical attraction.

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which is the same thing. Now, if we can show that these can be separated again, particle from particle, by the same agent that produces their union, then we, by inverse reasoning from effect to cause, prove beyond the possibility of mistake, that electricity is the efficient agent in the production of all chemical changes. And this has already been shown in the record of certain experiments, contained in the quotations of the last lecture.

It will be recollected by those who read the former lecture carefully, that, by the experiments of Berzelius and Hisinger, with a galvanic battery, as described by them in 1802, in Gehlen's Journal, various salts in solution were separated or decomposed, and the acid of the solution was deposited around the positive pole and the base or alkali around the negative pole, in accordance with an immutable chemical law of the attraction of unlike polarities.

The experiments of Sir Humphrey Davy, abundantly confirm those of *Berzelius* and *Hisinger*. *He found* that, by increasing the energy of his battery sufficiently, and with appropriate apparatus for the purpose, he could decompose any compound body whatever, the negatives in all cases collecting around the positive pole, and the positives around the negative pole, thus proving that the electric agent, will separate compounds, as well, as form them, which we have heretofore proved.

A question may here arise, as to the correctness of our theory upon the subject of ponderable matter. We have assumed that it is a simple essential principle, and that all its infinite variety of modfications of every kind, are caused alone by the imponderable principle, which controls and arranges all its particles, as we find them arranged.

Now this may be denied from the fact, developed by the experiments of the beforementioned chemists, that one ingredient of a compound in solution goes to one pole of a galvanic battery, and the other to the other pole. It may, from this fact, and with great seeming plausibility, be argued that the two ingredients, which go to opposite poles, called alkalies and acids, must be matter inherently different from each other, and that, on account of that inherent difference, the separation takes place. Such an inference, however, does not necessarily result from the premises. It can, in fact, be shown to be erroneous. It is not separated into constituent ingredients by any repulsive force, which exists within it inherently, because, if such repulsive *inherent* force *did* actually exist, the acids and the alkalies would not, under other circumstances, exhibit an attractive affinity at all, but would forever, and under every possible variety of conditions, exhibit the same stubborn repulsive power, and, therefore, never amalgamate, as they do, when a new compound is formed, by the effervescence of tartaric acid and soda.

This fact, that repulsion takes place under one set of circumstances, and attraction under another, speaks volumes in favor of the validity and truth of the proposition, that the alkalies and acids are united as in solution, and separated again, as in the galvanic experiment, *entirely* in both cases, by the force of electricity, exerted over their particles. This must, in reality, amount to a demonstration, in the view of every mind acutely philosophic.

"But," says the enquirer after true science, "there must be something inherently different in the nature of the particles of the alkalies and the acids themselves, or else the positive pole of the battery would not attract the acid, nor the negative the alkali, but they would move indiscriminately either way, and not be decomposed at all." This assertion, however, is predicated upon the supposition that a particle, that was alkaline before being compounded by a chemical union, is also, alkaline, when separated by the energy of the galvanic battery. But, at the risque of differing with the whole body of chemists, we shall affirm, that this, by no means follows as a necessary consequence. It certainly can, with great plausibility, at least, be made a question, whether particles may not move indiscriminately to *either* pole, and there, by the peculiar influences, which we know the two opposite poles of a galvanic battery exert over substances in contact with them, and which are confessedly very mysterious, be made either alkaline or acid by that contact.—This supposition we know would do violence to the prejudices and prepossessions of many scholars. But why should it? Does not electricity evidently demonstrate, that, within its own inherent organic nature, is laid *alone*, the basis of the alkalies and the acids, by the experiment upon the tongue with the inward and the outward current of a galvanic battery? This will not be denied and cannot be, for "facts are stubborn things," which cannot be gainsayed, nor resisted. Are they not, also, as we have abundantly shown, both decomposed and recomposed, and therefore, controled by the electric agent, which would not, and could not be the case, if the two apparently opposite ingredients, which form the compound, were inherently different in their own organic nature, independent of the influence of imponderable matter? Most certainly. For they would never thus separate and unite again, did the force, which controls these opposing movements, reside within themselves. Besides, it is a fact revealed by both the researches of geology, and the experiments of chemistry, that the very same substance or mass of substances, yea, the very identical ultimate particles of a substance, may change their nature from age to age, by chemical processes wrought upon them.

A substance, for instance, may have been animated flesh and bones, as in the mighty army of Xerxes, when he invaded Greece. That army, having been mowed down upon the battle field by the victorious invaded, may have mingled with the soil, upon which they fell, and, by their putrid blood, and flesh and crumbling bones, have made the soil luxuriant. Out of it may have shot up a fores upon the desolated waste, and this flesh and blood and bones hav been reformed into a grove of stately trees. These trees, in th revolutions of time, may have been swept away and buried by a deluge. There, within the bosom of the earth, they may have undergone another change, and have been reformed either into solid rock, or beds of bituminous coal, to become the subjects of still further, and equally remarkable transformations, being burned, and resolved into vapors, gases, ashes & electricity, & prepared to enter, in this state, into the composition of an almost endless variety of other substances. This supposition, which we have made for the sake of illustration, is no fanciful chimera of the brain, but well authenticated reality.

Geology & chemistry prove, that such transformations have been occurring in all ages, and that they are continually occurring at the present time. And lest it should be said, for the purpose of weakening or attempting to invalidate our argument, that such transformations are never made of a substance, except the new formation be of the same nature as the old one, out of which the new was organized, and, that a combustible furnishes the material for a new combustible formation, as wood and other vegetable matter, for instance, form bituminous coal, we would reply that such an assumption is proven false entirely, by the transformation of wood into that kind of stone of the hardest and finest quality, which is called " the hone, " by depositing the wood a few years in one of the lakes of Ireland.

We might extend our remarks upon the subject of the chemical changes of the character spoken of, until they should fill volumes, for they are almost infinite in variety. But sufficient has been already said to prove to a demonstration from the data of incontrovertible facts, that the forces by which chemical changes are wrought in ponderable matter, do not reside inherently in the substances themselves, or belong to their organic nature ; for if they did thus reside, we hold it to be a proposition capable of the clearest and most logical demonstration, that no such transformation of substances could ever possibly occur, but there would; then be one changeless, unvaried scene, where now all is variety and ceaseless mutation.

We now leave this branch of our subject, with the feeling, however, that much more might be said, had we time and space, and that what we have said might have been vastly more appropriate, had we the ability of some, to whose attainments we presume not to aspire. In a subject as abstruse as that of the principle of chemical affinities, it must be expected that very many things will be passed over, without being made perfectly plain, and intelligible to all. Our object has been mainly to seize upon strong positions of lucid proof, where there could be no mistake or deception in our reasonings, or evasion of their propriety by others, and then from such strong positions draw reasonable and logical inferences, respecting subjects more abstruse and difficult.

The electrical condition of oxygen and hydrogen gas—and more particularly of oxygen, we shall now consider minutely, because it is, as we shall show, the most essential agent in chemical changes that exists.

There are, in the quotations which we made in the last lecture, two clashing theories respecting the relative electrical state of those two gases.

M. Pouillet, a distinguished chemist, by a variety of experiments, very carefully conducted, as we have seen in the quotations of the last lecture, came to the conclusion, that oxygen gas was positive and hydrogen negative.

Sir Humphrey Davy, on the contrary, from the test of experiment, came to the conclusion in the same quotations that oxygen is negative and hydrogen positive.

With this opinion of Davy, Mr. Thomson, who collocated the testimony of the two, and from whose valuable work we made the extracts, seems to coincide.

Now, when such men of deep and careful research, and critical intellectual acumen as Pouillet, Davy and Thomsom *disagree*, and take positions directly opposed to each other, what shall we do, to determine which is right, and which is wrong, for right, *both* certainly cannot be? Why, examine critically the positions of each, according to the best light we have, and endeavor, if possible, to ascertain where the *error* lies.

The first subject of investigation is oxygen, which, as we said before, is a very essential agent in the chemical changes, which are continually occurring throughout nature.

This gas wes discovered by Dr. Priestly, in 1744, There have, since its discovery, been given, several appellations. indicative of its nature. Priestly called it dephlogisticated air. It was called *empyreal air*, by Scheele, and vital air by Condorcet. Lavoisier gave it the name, which it now bears, derived from two Greek words, which signify *to generate acid*, from its being considered by him the sole cause of acidity.

This gas is colorless, has neither taste nor smell, is heavier than atmospheric air, has not, by any experiment hitherto made, been decomposed, is a non-conductor of electricity, emits both light and heat by the force of sudden compression, and, according to the opinion of some, is the most perfect negative electric in existence, always appearing at the positive pole, when any compound, which contains it, is exposed to the action of galvanism, which opinion, we shall, however, endeavor to show, is entirely unfounded.

Oxygen has a very powerful affinity or attraction for most simple substances, and, indeed, it may be made to combine with all.— By such combination, it oxidizes or corrodes the metals, which oxidation is a species of combustion. It is also, the sustaining principle of fire; for the sole reason, why fuel burns freely in the open air, or is smothered by cutting off its communication with the atmosphere, is because, in the one case, its ignition is sustained by its affinity for oxygen, which it attracts from the air, and, in the other, is deprived of an appropriate supply to produce the chemical change of vegetable oxidation.

All substances which will burn in the open air, will deflagrate much more rapidly and brilliantly in oxygen. If there be the least perceptible spark, for instance, upon a piece of wood, it will instantly burst into a fierce blaze, when inserted in a jar of this gas.—And even steel and iron will burn with rapid and intense brilliancy, when thus inserted. The moment, however, that the oxygen is exhausted by chemical combination with the burning body, the ignition ceases, although the substance may not have been entirely consumed.

There are other interesting phenomena still, which will illustrate the nature of oxygen gas. It seems to be an absolutely essential agent in respiration. No animal can live by inhaling an atmosphere which does not contain a certain portion of oxygen, uncombined with other substances: for he will die very soon, if forced to breath the air, out of which the oxygen has been entirely extracted. If a lighted candle or taper be immersed in it its flames will be extinguished. Respiration and combustion therefore require the presence of the same sustaining agent. An animal cannot live in an atmosphere which is unable to support combustion: nor, in general can a candle burn in air which contains too little oxygen for respiration.

There is another singular property about oxygen. Although certain portion of it is absolutely necessary to sustain respiratio yet an unmixed atmosphere of pure oxygen is as fatal to life as i destitution, though not so speedy in its effects. "When an anima as a rabbit for instance, is supplied with such an atmosphere, no i convenience is at first perceived, but, after an interval of an hour more, the circulation and respiration become very rapid, and the sy tem in general highly excited, symptoms of debility subsequent ensue, followed by insensibility, and death occurs in six, ten or twel ours. On examination after death, the blood is found highly florid in every part of the body, and the heart acts strongly even after the breathing has ceased."

From the facts described above, these are the influences, in substance, of oxygen gas. It is the prime agent of the oxidation of all metals, the great supporter of combustion, and gives vitality, warmth and purity to the blood, as it circulates through the system.

Now are these the influences of a negatively electrified body?—Will a substance, which is minus, aid in sustaining flame, while one that is plus puts it out? Is there any thing in the inherent nature of positive electricity to produce such a result? Is it either a principle of cold or dampness, that it should extinguish fire or chill the blood during respiration? It seems to us that any one, who understands the nature of the electric agent, can be at no loss for a ready answer. Even plain, unlettered common sense, could hardly fail of coming to a correct conclusion. Such properties as belong, inherently to oxygen gas, and such agencies as it exhibits, beyond controversy or the possibility of mistake, in contact with various substances, are entirely inconsistent with the properties and the agencies, which we know belong to negative bodies. Carbonic acid gas, for instance, is a negative body. Does it sustain combustion or respiration, as, reasoning from analogy, we should suppose it would? No. But its influences are directly the reverse of those ascribed to oxygen gas. Instead of sustaining the ignition of fuel, it immediately extinguishes flame, and instantaneously stops respiration, instead of promoting it. Now, if the maxim, that "like causes produce like effects," be a self-evident proposition, as it doubtless is, *can* oxygen gas and carbonic acid gas be *both* negative bodies, when the inherent properties and agencies of the *one* are directly the antipodes of the *other?* The conclusion that they are, must, it appears to us, be considered, when viewed in the light, either of sound logic, or unlettered common sense, as preposterous in the extreme. The fact is Pouillet was right and Davy and Thomson, his opponents in theory, were wrong. Oxygen *gas is positive*, for no agent can exhibit the same influences, without being positive, if there be any certainty at all in the source of our chemical knowledge.

The further discussion, however, of this interesting and important subject must be deferred to the next lecture, where we hope, by an array of facts and arguments, to prove conclusively, that oxygen *gas is* positive, and also satisfactorily reconcile those phenomena with this theory, where it may seem to be negative.

LECTURE VII.

SUBJECTS—OXYGEN—HYDROGEN.

THIS lecture will be a continuation of the description of those facts connected with electricity, which have been developed by galvanism, and by experiments in other departments of chemistry, as well as an examination and exposure of falsities in theory.

The first subject of attention and remark will be oxygen gas.—We have already, in a former lecture, described some of its most essential agencies, and endeavored to show, by conclusions drawn from both reason and analogy, that those agencies were entirely, inconsistent with the idea of a negative body, for we could not see what principle there was in mere negative electricity, or a mere absence of it, to support combustion, so as even to make iron and steel deflagrate with intense brilliancy, or how it should, as we shall endeavor to prove that it does, impart vitality and warmth to the blood, supply fuel for that steam engine of organic life, the heart, and enable it to propel the purple current with such force through all the channels made for its circulation through the system. As the opinions of Davy and Thomson upon this subject were, beyond the shadow of a reasonable doubt, incorrect, and as they clashed with the conclusions to which Pouillet came, by experiments equally cautious and critical, it may be well to examine the premises, from which they drew their conclusions, and see if they have not mistaken them in some very essential matters.

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have stubborn prepossessions to overcome. Yet we by no means despair of convincing even these, except there be some among them, that consider great names a sufficient demonstration of the truth of a proposition, which they may advocate, no matter how lame may be their arguments, nor how contrary to fact their reasonings.

If oxygen gas be positive, why does it disobey that law, which as we have seen, regulates all positive substances, and go to the positive pole, instead of going to the negative, as they all do. Simply because it is a *cause* instead of an *effect* as in the other cases alluded to. It is electricity instead of an *effect* merely of electricity.

The acids, being negative, move to the positive pole, because opposite polarities, according to the inherent laws of opposite polarities, bring them there. But oxygen rises from the positive pole *for another* reason essentially *different*. It is constituted by the positive current itself, instead of being collected and constituted by any mere *effect* of that current, and rises, therefore, from its own pole, instead of moving to the negative pole, and there rising. This we conceive to be the *only* rational and plausible, and indeed the only *possible* reason why oxygen, if positive, is uniformly found at the positive pole of the battery, while all negatives move there, according to the laws of electrical attraction :—for, unless it be, as we have assumed, *electricity itself*, instead of any *effect* merely, no reason could be assigned for its moving to that pole, except it were negative, which, as we have already shown, cannot, in accordance with the uniformity of natures laws be correct.

"But," says the objector to this proposition, "electricity, or galvanism, is an imponderable principle, which exhibits no perceptible weight at all, but oxygen gas is a substance, more dense than most gases, and heavier even than atmospheric air."

That we acknowledge is true. It is heavier than the atmosphere, and electricity exhibits no weight at all, that can be detected by the very nicest and minutest ballances. But does this disprove our solution of this apparent anomaly. By no means. It may contain the plus current of the battery, which, however, in its action upon the water, collects to itself certain weighty constituents of that water, which it forms into the vehicle or medium, in which it is borne, the same as vapor, which is an association of mere vesicles, formed of certain constituents of water, enclosing caloric, the generating agent, which, by the way, will illustrate, the formation of oxygen gas. During the generation of vapor by caloric, no positive electric effects are perceptible, according to the testimony of M. Pouillet and Thomson. In this case, caloric is the *cause* of the vapor, arranging for particular use, the watery constituents of the vesicle, in which it encases itself, and becoming invisible and imperceptible during that encasement. When, however, by the proximity of any chemical attractions or affinities, which call it forth from its encasement into visibility, and make it burst the vaporous vesicle, which it had formed for itself, it then exhibits the phenomena of positive electricty distinctly and strongly marked, as we shall abundantly show, when we come to the cause of the nimbification and electrical discharges of the stormcloud.

Now, what caloric does for itself, in the formation of its vaporous vesicle, we consider that the positive current of the galvanic battery does for itself, in the formation of an encasement for itself, out of certain dense and weighty ingredients of the water;—which cause, together with its encasement, constitutes that heavy, invisible vaporous air, which we call oxygen gas.

While thus encased, its positive properties, like the creating agent of the vapor of water, are imperceptible, and are never revealed, except when certain strong chemical affinities, or attractions call it forth from its imperceptibility, and make it burst assunder the encasement, in which it had hidden itself, and show the resistless energies of its nature.

In this way, and in this *alone*, it seems to us, can the appearance of the positive oxygen at the positive pole of the battery, be accounted for, when all other positive substances go to the negative pole. It is a *cause* rather than a *result*. It is positive or plus electricity, so encased as we have described, rather than any effect in the same sense, as the collection of an acid around the positive wire can be considered an effect.

Oxygen gas, has ever since its discovery by Priestly, been considered a simple substance, and been thus classified. But the reason of this is, because no chemist has yet been able to decompose it, and demonstrate that it is a compound. There can, however, be no doubt as to its being a compound body, if electricity, in combination with certain ingredients of ponderable matter, can be called a compound body. This is proven by the fact, that, although chemists have not been so fortunate as to succeed in decomposing it, it has been decomposed, and is continually undergoing a process of decomposition, in that natural chemical laboratory, far more perfect than any artificial one, possibly can be—*the lungs*—as we shall show abundantly in another connection.

Now, the reason why chemists have not succeeded in decomposing this agent, and resolving it into its elements, is, we presume, owing to the fact, that the essential or causating principle, is so very subtle, that it cannot be controled, and so very powerful, that its attractions for its encasement resist all the counter attractions, which chemists have arrayed around it.

Hydrogen gas, which is the opposite of oxygen, will now be briefly examined for a little while, and afterwards we shall remark upon some influences of both in connection, which will further illustrate this subject.

This gas was formerly called *inflamable air*, from its supposed combustibility, and *phlogiston* from the supposition that it was the matter or principle of heat. But its present name is compounded of two Greek words, which signify to *generate water*, from the fact that when changed by combustion, it constitutes water.

As we are obliged, in support of the proposition, that hydrogen is negative, to examine the subject critically, and to show the falsity of prevailing theories upon the subject, we shall first quote the language of a celebrated author, and then examine those sentiments for ourselves. Here follows an extract from Turner.

"Hydrogen is a colorless gas, when pure, has neither odor nor taste, and is a powerful refractor of light. Like oxygen, it cannot be resolved into more simple parts, and, like that gas, has hitherto resisted all attempts to compress it into a liquid. It is the lightest body in nature, and is consequently the best material for filling balloons. From its extreme lightness it is difficult to ascertain its precise density by weighing; because the presence of minute quantities of common air or watery vapor occasions considerable error.

"Hydrogen does not change the blue color of vegetables. It is sparingly absorbed by water, 100 cubic inches of that liquid dissolving about one and a half of the gas. It cannot support respiration —for an animal soon perishes when confined in it. Death ensues from deprivation of oxygen rather than from any noxious quality of the hydrogen; since an atmosphere composed of a due proportion of oxygen and hydrogen gas may be respired without inconvenience. Nor is it a supporter of combustion; for when a lighted candle fixed on wire is passed up into an inverted jar full of hydrogen gas, the light instantly disappears.

"Hydrogen gas, is inflamable in an eminent degree, though, like other combustibles, it requires the aid of a supporter of combustion. This is exemplified by the experiment above alluded to, in which the gas is kindled by the flame of a candle, but burns only where it is in contact with the air. Its combustion, when conducted in this manner, goes on tranquilly, and is attended with a yellowish-blue flame and a very feeble light. The phenomena are different when he hydrogen is previously mixed with a due quantity of atmospheric air. The approach of flame not only sets fire to the gas near it, but the whole is kindled at the same instant; and a flash of light passes through the mixture, followed by a violent explosion. The best proportion for the experiment is two measures of hydrogen to five or six of air. The explosion is far more violent when pure oxygen is used instead of atmospheric air, particularly when the gases are mixed together in the ratio of one measure of oxygen to two of hydrogen.

" Oxygen and hydrogen gases cannot combine at ordinary tempertures, and may, therefore, be kept in a state of mixture without even gradual combination taking place between them. Hydrogen may be set on fire, when in contact with air or oxygen gas, by flame, by a solid body heated to bright redness, and by the electric spark. If a jet of hydrogen gas be thrown upon recently prepared spongy platinum, this metal almost instantly becomes red-hot, and then sets fire to the gas, a discovery which was made in the year 1824, by Professor Doebereiner of Jena. The power of flame and electricity, in causing a mixture of hydrogen with air or oxygen gas to explode, is limited. Mr. Cavendish found that flame occasions a very feeble explosion when the hydrogen is mixed with nine times its bulk of of air; and that a mixture of four measures of hydrogen with one of air does not explode at all. An explosive mixture, formed of two measures of hydrogen and one of oxygen gas, explodes from all the causes above enumerated. Biot found that sudden and violent compression likewise causes an explosion, apparently from the heat emitted during the operation; for an equal degree of condensation, slowly produced, has not the same effect. The electric spark ceases to cause detonation, when the explosive mixture is diluted with twelve times its volume of air, fourteen of oxygen, or nine of hydrogen; or when it is expanded to sixteen times its bulk by diminished pressure. Spongy platinum acts just as rapidly as flame or the electric spark in producing explosion, provided the gases are quite pure and mixed in the exact ratio of two to one.* Mr. Faraday finds that platinum foil, if perfectly clean, produces gradual though rather rapid combination of the gases, often followed by explosion. (Phil. Trans. 1834.)

"When the action of heat, the electric spark, and spongy platinum no longer cause explosion, a silent and gradual combination between the gasses may still be occasioned by them. Sir H. Davy observed that oxygen and hydrogen gases united slowly with one another, when they are exposed to a temperature above the boiling point of mercury, and below that at which glass begins to appear luminous in the dark. An explosive mixture, diluted with air to too great a degree to explode by electricity, is made to unite silently by a succession of electric sparks. Spongy platinum causes them to unite slowly though mixed with one hundred times their bulk of oxygen gas."

In the examination of this subject, and in commenting upon the facts developed and the positions taken in the extract, we shall do it in the order in which they occur in that extract.

It is said that "hydrogen gas cannot support respiration." And why not? It is affirmed that it is not because it contains any deleterious quality, but because it is simply deficient in oxygen. We grant that all this is true. It will not support respiration and consequently life, when unmixed with oxygen, simply for the want of that oxygen.

Now what is there in the oxygen and not in the hydrogen, which supports respiration and life? We affirm that it is *positive* electricity, with which the oxygen is charged, and of which the hydrogen is almost entirely deficient. By examining the phenomena of respiration in the strong light of the facts, which chemistry throws upon the subject, we shall be convinced that this is the case. What are the phenomena of respiration?

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*For a variety of facts respecting the causes which prevent the action of flame, electricity, and platinum in producing detonation, the reader may consult the essay of M. Grotthus in the Ann. de Chimie, vol. lxxxii.; Sir H. Davy's work on Flame; Dr. Henry's essay in the Philosophical Transactions for 1824; and a paper by myself in the Edinburgh Philosophical Journal for the same year.

When atmospheric air is drawn into the lungs by inhalation, a remarkable chemical change takes place, through its influence upon the dark venous blood in its passage through the lungs, where, in the inubmerable veins, and air cells it comes in contact with the atmosphere. The oxygen of the atmosphere is decomposed, the imponderable principle of the oxygen, or its electric cause, enters into the blood, neutralizes by a chemical change, certain deleterious properties, which, if retained in the blood, would destroy life, the ponderable encasement, of the imponderable principle, whatever that encasement be, is exhaled again, the blood changes from a dark purple to a florid red color, in part by being unloaded of its carbonic acid gas, and the streams of life are purified from all stagnating causes and qualities, vivified and filled with their vital and energizing warmth, by the electricity infused into them. Is not this, in brief, the reason why oxygen gas is necessary for the support of life? Is not animal heat or the heat and consequent fluidity of the blood caused by the positive electricity contained in it? Is not this in fact, the principle of mere animal life, since the blood is that animal life?— Were this gas *negative*, could its effects upon the blood be such as we find them? Could a *negative* body impart *heat* at all, since the absence of electricity is the absence of the *essential principle* of fire or heat? The appropriate answer to these questions is perfectly obvious. All must, we think, from these facts and reasons, conclude that oxygen is, and *must* of necessity be, *positive*, and hydrogen is consequently *negative*, since it is the very opposite of oxygen. But there is still further proof to be drawn from the extract itself.

Some there may be, who may still affirm with the books, that hydrogen must be positive, since it is known to be "inflamable" in an eminent degree" in the language of the extract from Turner, and, there fore, contrary to the assertions above, it must contain the princip of fire. But chemists have been entirely at fault in this position.- The fact is, it is *not inflamable at all*, which fact is capable of such lu cid and perfectly logical demonstration, as must satisfy every ingenuous and unprejudiced mind.

Although hydrogen is affirmed to be inflamable, yet, it is said, in the same breath, that it is "not a supporter of combustion," which is a palpable contradiction in terms. Can any substance contain the principle of fire, or be combustible, without having, at the same time the power to sustain combustion? The thing is impossible.— "When," in the language of Turner, "a lighted candle, fixed on a wire, is passed up into an inverted jar full of hydrogen gas, the light instantly disappears." Now why is this? If hydrogen were *inflamable*, would it put *out* fire? The idea is perfectly absurd. One might just as well, and with just as much reason affirm, that fire would put out fire, as to affirm that an inflamable gas would put out fire.

To show the difference between the two gasses, if a lighted candle be inserted in a jar of hydrogen, it will be extinguished, but if there be the least spark or smoke at the end of the wick, and it be inserted in a jar of oxygen, it will be instantly relighted, and so, by inserting the candle alternately in hydrogen and oxygen, it will alternately be put out and relighted, until the two gasses escape, or the candle is consumed. Now which appears, by this experiment, the most like a *positive* gas, hydrogen or oxygen? The one extinguishes flame and the other relights it. Which then seems to be *inflamable*? Common sense can answer that question, and this must be its answer.— That substance must be *inflamable* which will aid to burn a body instead of extinguishing it, when on fire.

But the question may here be asked, why hydrogen gas will burn, as in the cases enumerated in the extract we are considering? We answer unhesitatingly that it will not burn at all, that it never did and never will. It will inflame, it is said, by the application of a lighted candle, when in contact with atmospheric air, which contains oxygen, or else in contact with pure oxygen itself. But why is this?—Why must it come invariably in contact with a *supporter* of combustion? Simply for this reason. The hydrogen is negative and the oxygen is positive. That positive contains the principle of fire, or electricity, and is, therefore, a supporter of combustion. The negative is the entire absence of the principle of fire. The one is therefore, highly plus, and the other deeply minus, and when they are mixed, either by contact with the atmosphere, or with a certain proportion of the two gasses pure, they unite upon the application of flame with an explosion. This union and explosion are precisely in accordance with the known principles of electrical attraction. Between the two there exists the strong affinity of opposite polarities. The plus of the one is given out to the minus of the other, and this combustion is the result. But the fire depends, not upon the hydrogen, but upon the oxygen, for when it gives out its plus to the minus of the hydrogen, in the effort to restore an equilibrium between two opposites, that plus charge appears in the form of fire.—This and this *only*, it appears to us, is the cause or reason of the combustion, and must prove conclusively, that oxygen is highly positive, while hydrogen is deeply negative. There can not possibly, it seems to us, be any rational doubt about it.

There is another fact still in the extract, which, if left unexplained, may lead to false conclusions. It is this, "If a jet of hydrogen gas be thrown upon recently prepared spongy platinum, this metal almost instantly becomes red hot, and then sets fire to the gas."—Now this question may occur—if hydrogen be not *inflamable*, and if it contain not the principle of heat, how can it make the platinum *red hot?* This question we shall answer, by denying that any such effect is caused by the hydrogen simply. There is another way to account for the phenomenon—a way in more strict accordance with the known laws of chemistry. Platinum is a positive substance and is so classed in the list of positive substances, and hydrogen is negative, as we have seen. Now, when a jet of this gas is thrown upon the spongy platinum, why does that metal become red hot, unless the positive charge of the hydrogen make it so? This is the *philosophical* solution of the question. The hydrogen, being deeply minus, while the platinum, in comparison, is highly plus, the electricity or latent caloric of the metal rushes to its surface, where, by strong chemical affinities, a deeply minus substance calls it out and makes the plus substance red hot, by its own latent caloric, becoming visible. This is the law precisely of all *galvanic* action, and indeed of all *chemical agencies* whatever. A metal can be affected or decomposed in *two* ways. If a substance, highly plus, be brought, in solution or in the form of a gas, in contact with the metal, so as to have the facility, by that contact, of taking hold of its particles, the plus substance will decompose the metal more or less rapidly, in exact accordance with the difference in the respective amounts of latent caloric or electricity, which they contain.

If this position be correct, as it doubtless is, then we have a correct solution for the action of the galvanic battery. When the associated plates of zinc and copper, composing the battery, are plunged into a strong solution of nitric acid, the zinc plate is attacked by the acid, instead of the copper. And why? Because it is more positively charged than the copper. Rapid decomposition of the zinc is the consequence. And why? Because, it being plus and the acid minus, the latent caloric of the zinc, or its electricity, which makes it plus, *burns* its way out through the metal, to the deeply negitive body, which surrounds that metal, and thus decomposition takes place, latent caloric is set free by burning up the metal in its passage to the minus substance, for which it has a stronger affinity, and during this change, a portion of it escapes by the conducting poles of the battery.

d would act upon the copper in the same way it does upon were it associated with some other metal, which should be minus, or have less latent caloric than itself. This is pro- the fact, that, although the solution of nitric acid will not affect the copper, when associated with the zinc, yet, when me acid is poured upon the copper by itself, the copper is nsumed, the latent caloric burns its way out to the minus during the decomposition, which is attended with no small n, a purple vapor rises, which has almost the appearance

ygen gas corrodes or burns, or decomposes the metals for a st the *reverse* of that, which we have assigned for the action ls upon them. It is highly positive or plus. and, therefore, s latent fire, caloric or electricity, just which you please to the metals, instead of receiving it *from* them, as the acids in contact with them. The consequence is that it burns shes silently, as in the corrosion or oxidation of the metals, to a damp atmosphere, or with an intensly brilliant corrus- in their deflagration, when inserted in a jar of pure ox-

smiss this subject of the various influences and agencies of nd hydrogen, but more particularly of oxygen, not because n exhausted by any means, nor because it could not be ex- ith interest, for there could be a volume written without ng it, but because the design and limits of this work will not Enough, however, has been said, we think, by way of ar- nd proof, to demonstrate to the perfect satisfaction of ev- l, that is willing to be satisfied, that oxygen gas is positive, ogen gas is negative, and that the opinions of Pouillet, up- ubject were right, and those of Davy and Thomson, were Enough has, also, been said to show conclusively, that elec- an essential agent in the chemical changes, which wew [illegible] tness around us, and which are continually occurring throughout nature, and to prove that the actual cause of many of the wondrous phenomena, which come under the observation of chemists has been mistaken.

In our next lecture, we design to show, among other important facts, what an essential agent electricity is, in the preservation of health, and how. in some cases of disease, it may be of very important service, in counteracting the influences of that disease upon the system, and in giving tone and vigor to a debilitated constitution.

LECTURE VIII.

SUBJECTS—ANIMAL ELECTRICITY—ELECTRIC PATHOLOGY.

As intimated in a former lecture, we intend, in the present, to examine the chemical effects of electricity in another important department, perhaps the *most* important of human knowledge, into which, we have not, as yet, introduced the reader. We feel, as we enter it, our incompetency to do any thing like justice to the subject, for the agencies of electricity in the production of animal life—its indispensible necessity in the preservation of that life, and its remedial qualities open a vast field of most interesting investigation before us—a field hitherto but little explored—a field, every part of which, is full of such marvellous interest, that the Psalmist very properly exclaims, when contemplating it. *"I am fearfully and wonderfully made."*

If, in passing from the contemplation of inorganic matter to organic, we range through the various departments of the vegetable kingdom, and the lower order of animated existences, we find that the electric agent, or caloric, which we shall hereafter prove, is the same thing, is the grand *instrumental* cause of the germination of life. No acorn ever burst its shell and rose into a stately monarch of the forest—not one of the ten thousand various seeds of trees, of herbage and of flowers, that clothe and variegate the landscape, ever vegetated without the agency of heat. They would, forever, have lain dormant and lifeless in the cold and withering embrace of the earth, and, unwarmed into life by the genial influences of the caloric of the sunlight, this globe would have been covered with a chilling desolation, as blank as that of an ice-berg, and no more vegetation would have adorned it in a vesture of green, than would now spring up on the snow-banks of a December in Nova Zembla.

When we pass from the vegetable to the *animal* kingdom, we find the same great truth illustrated by a thousand facts. What generates life in the egg of the feathered tribe, and sustains and fosters it from the mere incipient embryo of existence, to the bursting of the shell by the little chick, as he starts into animation from his prison house? Why *caloric*, and caloric *alone*? If the hen, or any other animal of the feathered tribe, fails to brood over the eggs with unwearied constancy—if, during any portion of the gradual stages of the progression of existence, from the incipient enlargement of the impregnated ovary, to the period, when the shell is burst, the egg be left to cool below the equal temperature of animal heat, it becomes addled immediately and the principle of animation departs. Even where there is no incubation of the animal, the egg is still hatched by the agency of caloric. The Ostrich buries her's in the sands of the desert in the torrid zone, where she leaves it to be warmed into life by the influences of a vertical sun. The Serpent of the same zone, it is said, follows the example of the Ostrich, and, by the germinating power of the heated sand hills, peoples the burning wastes of Zahara with her venemous brood. Even that industrious little spinster, the silk worm, that fabricates from leaves, the imperial robes and vestments of monarchs, is brought into life by a similar process—by the application to the ovum of either natural or artificial heat.

But, although it may here be confessed, that caloric is absolutely necessary to the production of those forms of existence, to which we have alluded, yet, it may be denied, that this acknowledged generating agent is electricity, as we have affirmed. Leaving our main argument in proof of the position we have assumed, until we come to the subjects of solar light and heat, we would here ask, if caloric and electricity be not inseparable? Was there ever a distinct electrical phenomenon ot any kind, ever developed to the observation of chemists, or of any body else, without the distinct developement, at the same time, of a corresponding amount of heat;—or, more properly speaking, is not the electricity developed, in fact, nothing more nor less than the caloric, which is inseparably attendant upon every such development.

Friction is one of the main causes of the production of electricity. If amber, for instance, be rubbed, or a stick of sealing wax, they immediately become electrically excited, and will prove it by attracting to themselves contiguous light bodies. This is the case with a glass tube, or any other electric, when rubbed with dry silk, or woolen cloth. It is a fact well worthy of attention and remark, that *heat* is invariably produced by that friction. Now, are not the electrical phenomena, which are manifested by that friction, owing entirely to the latent caloric which is called out, and made visible, since it is ever developed by the exciting cause? Let us examine the catalogue of electrical facts, and see if we do not find still further confirmation of the proposition we have assumed, and sufficient to convince the sceptical.

According to the experiments of M. Pouillet, already recorded in this work, the gas that rises from burning charcoal is positively electrified. What is that but the evolution of caloric in a certain form?

By heating metalic rods at one end, and thus disturbing the equalization of their temperture, electric or magnetic phenomena make their appearance; for one end of such rods will be positive and the other consequently negative, as is exhibited plainly by their attractions and repulsions of the electrometer or magnetic needle. Here the character of the electrifying agent is so perfectly apparent, that there can be no mistake at all about it. It is caloric and nothing but caloric.

The galvanic battery in action, always produces heat. If the acidulated solution, into which the battery is plunged, is perfectly cold at the time of its immersion, that solution will be heated so rapidly, that it will, in some cases actually boil in less than three minutes. Now, what causes this great and sudden change in the temperature of the solution, except it be the latent caloric of the zinc set free by the process of the combustion of the metal, heretofore described, and which constitutes the galvanic current, and produces the galvanic effects of the battery? We feel that candid minds must be irresistibly brought to the same conclusion by these facts. That caloric, which heats the solution, *must* be the electric agent, and that electric agent, the caloric. There can possibly be no mistake about this.

All crystalizations of salts, and other crystalizations of whatever character they may be, exhibit electrical phenomena, and are always attended with the evolution of caloric. All freezing mixtures expel caloric rapidly, and evolve also electricity. According to the estimate of Dr. Hare of Philadelphia, the crystalization of vapour, which attends a snow storm, gives out more caloric than a shower of red hot pulverized glass, and we know that such crystalization of vapour is accompanied with electrical phenomena.

The further elucidation of the identity of caloric and electricty will be referred to its appropriate place—the discussion of the subject of solar heat, since in this connection, it is rather a digression from the topics we had selected. We shall there collocate, we think, such a formidable array of additional facts, as must convince the most sceptical unbeliever. But enough has been said, we presume, to prove that the caloric, which is the cause of the germination of all seeds, and the principle, which vivifies the embryo of the egg, is electricity and produces these effects by the known chemical influences of that agent.

breath becomes hot and scalding, and death makes rapid and giant strides upon the debilitated constitution.

Now for an explanation of the chemical cause of this condition of the system. It will be found, upon the closest scrutiny, that, in ninety-nine cases out of a hundred, when the above symptoms make their appearance, the stomach is filled with a cold, slimy, ropy, indigestible load, which is, of course, a deeply minus or negative substance. Now what are the *chemical* consequences of this negative substance upon the system? They are deleterious in the extreme, as will be explained, by a reference to an experiment in a former lecture. It will be reccollected that we demonstrated, that, if a current of galvanism be passed *in* to the tongue, it produces an acid taste in the mouth. This proves that an inward current of electricity is, in some mysterious way, the generator of acidity, which, as we have shown abundantly in another connection, is the reason why all acids are minus bodies.

The contents of the stomach, being minus or acid, will, of course, have an attraction for the plus or alkaline polarities of electricity, and the current will therefore be *inward* from the surface, which will be left cold, while those burning alkaline polarities, will irritate the internal coats of the stomach and intestines, the same as they are irritated in the cholera and other kindred diseases, and produce according to strict chemical laws and agencies all the fearful effects of those distressing and often fatal complaints.

There is a case directly in point, which came under our own observation, and which will forcibly illustrate both the effects and phenomena of the disease, we have been describing, and the appropriate chemical remedies for that disease.

Some seven or eight years ago, a young man, a printer by profession, while boarding in our family, was attacked one night most violently with a complaint almost akin to the Asiatic Cholera. Being reluctant to trouble the family, he made no one acquainted with

ly in the morning, we
had reclined, almost per-
sage to his chamber. See-
roused him, and aided him
at enough to see his complex-
ce and extremeties of his system
most like the collapsed or lethargic
racked with violent and almost spas-
ly sinking very rapidly into the arms of

nger immeditately for a physician, but
might possibly come too late, we concluded
in the mean time, to check the disease.--
d often complained of acidity of stomach, and
must be the primary cause of the distressing com-
ch he was groaning, we determined to administer
tly *chemical* principles. We accordingly mixed a
y strong sal soda, which he drank. We then took a
coarse flannel, filled it full of fourth proof brandy, and
t over thickly with ground black pepper. This we spread
stomach and bowels, and then covered him with an extra
of bed clothes. The result was surprising and almost
al. In less than twenty minutes an active reaction took place
e system. The cold, blue complexion left the surface. the
ntenance put on the natural hue of health,—a moist perspiration
rted out, the racking pains left him entirely, and he recovered
mmediately without further medical assistance.

Now, in this case, it is perfectly evident, that the cause of the disease was acidity. The matter in the stomach was deeply minus, the current of electricity was therefore, *inward* instead of being *outward*, and the surface and extremeties were consequently left cold, the blood, in thickened stagnated streams, pressed upon the heart and internal arteries. and, while the extremeties were almost rig the internal apparatus of vitality was parched with a burning, wi ering heat. To restore healthy action again, all that was necessa was simply, to reverse this order of the electrical condition of th system. This was done by neutralizing the minus with a plu *internally*, or an acid with an alkali, so as to give the current of elec tricity, an *outward* instead of an *inward* direction, by making the contents of the stomach plus, which would, of course, leave its internal coatings minus. and by aiding that outward current by the external application of brandy and pepper. Thus was the effect remov ed by removing the cause of that effect.

There are other diseases, that can be just as speedily cured by understanding fully the electrical condition of the human system, and then by making such an application of chemical remedies as to neutralize the cause.

Pulmonary complaints can be cured in ninety nine cases out of a hundred, where internal irritation or inflamation is the cause, by external blistering, or frequent and severe friction, provided it be attened with proper exercise and diet. And why? Because it is an invariable law, that, if the outer surface is plus the inner is minus and if the outer is minus the inner is plus.

Now if the inner be plus or inflamed, what is to be done? Why simply produce a counter irritation, by blistering or otherwise, and keep up that irritation sufficiently long to permit all ulcerous affections to heal, as they will, when the current of electricity is outward, as we shall illustrate more fully after having entered into an examination of the blood and its agencies. This examination, we shall preface by an extract from Liebig's "Animal chemistry."

"If we hold, that increase of mass in the animal body, the development of its organs, and the supply of waste—that all this is dependant on the blood, that is, on ingredients of the blood, then only those substances can properly be called nutritious, or considered as food which are capable of conversion into blood. To determine, therefore, what substances are capable of affording nourishment, it is only necessary to ascertain the composition of the food, and to compare it with that of the ingredients of the blood.

The substances require especial consideration as the chief ingredients of the blood; one of these separates immediately from the blood when withdrawn from the circulation. It is well known that in this case blood coagulates, and separates into a yellowish liquid, the *serum* of the blood, and a gelatinous mass, which adheres to a rod or stick in soft, elastic fibres, when coagulating blood is briskly stirred. This is the *fibrine* of the blood, which is identical in all its properties with muscular fibre, when the latter is purified from all foreign matters.

The second principle ingredient of the blood is contained in the serum, and gives to this liquid all the properties of the white of *eggs*, with which it is identical. When heated, it coagulates into a white elastic mass, and the coagulating substance is called *albumen*.

Fibrine and albumen, the chief ingredients of blood, contain, in all seven chemical elements, among which nitrogen, phosphorus, and sulphur are found. They contain also the earth of bones. The serum retains in solution sea salt and other salts of potash and soda, in which the acids are carbonic, phosphoric, and sulphuric acids. The globules of the blood contain fibrine and albumen, along with a red coloring matter, in which iron is a constant element. Besides these the blood contains certain fatty bodies in small quantity, which differ from ordinary fats in several of their properties.

Chemical analysis has led to the remarkable result, that fibrine and albumen contain the same organic elements united in the same proportion, so that two analyses, the one of fibrine and the other of albumen, do not differ more than two analyses of fibrine or two of albumen respectively do, in the composition of 100 parts.

In these two ingredients of blood the particles are arranged in a different order, as is shown by the difference of their external properties; but in chemical composition, in the ultimate proportion of the organic elements, they are identical

This conclusion has lately been beautifully confirmed by a distinguished physiologist (Denis,) who has succeeded in converting fibrine into albumen, that is, in giving it the solubrity, and coagulability by heat which characterize the white of egg.

Fibrine and albumen, besides having the same composition, agree, also in this, that both dissolve in concentrate d muriatic acid, yielding a solution of an intense purple color. This solution, whether made with fibrine or albumen, has the very same reactions with all substances yet tried.

Both the albumen and fibrine, in the process of nutrition, are capable of being converted into muscular fibre, and muscular fibre is capable of being converted into blood. These facts have long been established by physiologists, and chemistry has merely proved that these metamorphoses can be accomplished under the influence of a certain force, without the aid of a third substance, or of its elements, and without the addition of any foreign element, or the separation of any element previously present in these substances.

If we now compare the composition of all organized parts with that of fibrine and albumen, the following relations present themselves—

All parts of the animal body which have a decided shape, which form parts of organs, contain nitrogen. No part of an organ which possesses motion and life is destitute of nitrogen ; all of them contain likewise carbon and the elements of water, the latter, however, in no case in the proportion to form water.

The chief ingredients of the blood contain nearly 17 per cent. of nitrogen, and no part of an organ contains less than 17 per cent. of nitrogen.

The most convincing experiments and observations have proved that the animal body is absolutely incapable of producing an elementary body, such as carbon or nitrogen, out of substances which do not contain it; and it obviously follows, that all kinds of food fit for the production either of blood, or of cellular tissue, membranes, skin, hair, muscular fibre, &c., must contain a certain amount of nitrogen, because that element is essential to the composition of the above named organs; because the organs cannot create it from the other elements presented to them; and finally, because no nitrogen is absorbed from the atmosphere in the vital process.

The substance of the brain and nerves contains a large quantity of albumen, and, in addition to this, two peculiar fatty acids, distinguished from other fats by containing phosphorus (phosphoric acid,) One of these contains nitrogen (Fremy.)

Finally, water and common fat are those ingredients of the body which are destitute of hydrogen. Both are amorphous or unorganized, and only so far take part in the vital process as that their presence is required for the due performance of the vital functions. The inorganic constituents of the body are, iron. lime, magnesia, common salt, and the alkalies."

The above extract from Leibig, though a partial digression, has, nevertheless, been introduced, because it contained two important facts—first that the increase of growth and weight in the human system, depend mainly or wholly upon the blood—and secondly that the blood contains all those inorganic constituents. of which the organic is composed. The blood, then, it seems, is the chief agent in the distribution to different parts of the system, of the nutriment, which either builds or repairs the organic structure, and supplies what is wasted. All the chemical changes then, which transform the vegetable and animal nutriment into chyle,, the chyle into blood, and the blood into flesh and bones and nerves and muscles—the gastric juice, the saliva, the tears and every other secretion are performed through the medium and influence of the heart, veins and arteries.

It

A very interesting question here suggests itself naturally to the mind respecting the particular cause and the "modus operandi" of these multiform agencies, whose solution we confess is very difficult, but which can be somewhat elucidated by certain familiar facts of ordinary occurrence, from which certain common sense conclusions can be logically drawn. How does the blood resolve the constituents of food and flesh, or distribute its healthful and nutricious qualities to the organic mass of the system, and expel from that system those portions which are deleterious to animal life and vigor.

These questions can better be answered, after examining the phenomena of respiration. The blood, when simply considered in regard to its component elements, has no inherent power whatever to produce chemical changes, and to convert food into the component materials of the system, and separate that which is baleful and unhealthy from that which is not. That agency, so powerful and wondrous, belongs to the imponderable principle of the oxygen gas, which is inhaled by respiration, and to that *alone*, and that, as we have now made abundantly proven, is positive electricity. The all pervading electric agent, after all, does the work. And what are the phenomena attending some of its operations?

The lungs, as we have seen, are the grand labarotory, where almos the whole chemical changes of the human system are effected. In them the venous blood is transformed to the arterial, for the venou blood is one substance, and the arterial quite another—that is the on possesses some ingredients, which the other does not, or else the on possesses some ingredients in greater proportion than the other.—The venous blood in its passage through the veins, along the cours of the lymphatics and by the absorbents and secretory organs of th system, brings along a load of carbon and other matters deposited b the food in different parts which are at war with life, and which, if not expelled from it, would bring this wondrous but frail teneme down into the unorganized mass of mere lifeless material, out of which it was constructed—the venous blood, we say, brings along his load, in its passage through the lungs, and there exposes it to the action of the oxygen of the atmosphere, by which it is all decomposed when the breathing apparatus performs its appropriate duties, the carbon is expelled in the form of carbonic acid gas, a most deleterious poison, and other pernicious materials find vent in the same way.—The blood being purified from those substances, which will not aid in the construction, stability and healthfulness of the organic system, and changed or arterialized from a dark purple to a florid red color, bounds on its gladsome course, with greater elasticity, making the spirits buoyant and spreading the flush of health over the cheeks.

From these facts, which are incontrovertible, and can be tested it will be very readily perceived, what must be the fatal or pernicious consequence of any defect in the chest, either natural, or acquired by those sedentary or slothful habits, by which the breathing apparatus is circumscribed or compressed, so that the air cells cannot be expanded and completely filled at every inhalation by the vivifying and purifying oxygen. By such defect, it is evident that but a small proportion of oxygen would be brought in contact with the blood.—Of course but a small quantity of those deleterious substances, about which we have remarked, would be decomposed and expelled by it. Being retained in the system, they would aid to pull down, rather han build up, to enfeeble rather than strengthen the body, the lungs would become tuberculous and ulcerated, the liver inflamed, the eart and whole arterial system diseased, and the citadel of life would e prematurely and inevitably stormed and sacked by the invading orces.

How very essential is the knowledge of this fact to parents, guarians and teachers in the physical education of children committed to heir care and culture. If they would give them a healthy constituion, they must pay particular attention to the developement of this curious apparatus of animal life—the grand laboratory in which are wrought the chemical changes, the decompositions and the recompositions, that build up and beautify, or pull down and deform the organic structure; for, to use an appropriate figure, the lungs are the furnace, the blood is the liquid of life, and oxygen is the fuel that heats it up, and makes that steam engine, the heart, propel the streams of vitality through all their purple channels. If the furnace be compressed from any cause—if it be cramped and small, the quantity of fuel consumed will, of course, be proportionably less, feebler will be the strokes of that engine and more dull, languid and stagnated will be the current of life.

It is plain, then, that the system of hot house culture, which prevails to too great an extent at the present day, is *all wrong*. Children should not be brought up in the shade. They should be permitted and encouraged to engage in those animating sports in the open air, which quicken the respiration, and inflate and distend, to their utmost capacity, every air cell of the lungs. Yes, they should snuff up with delight the brisk breezes and face the keen north wester when Farenheit is five or ten degrees below zero. By such a course of physical education, it is perfectly evident that the foundation must be laid for a healthy constitution by giving a round full developement to the lungs, in which the streams of life are purified and prepared for the healthful construction of the physical organization.

In this connection we will notice a few phenomena, whose cause is not generally understood, and which will throw light upon this interesting subject we are discussing.

It is a fact well known to every observer, that children consume vastly more food in proportion to their bulk than adults; but the reason why they do, is not so obvious. There is, however, a definite chemical cause. Children breathe much more rapidly than grown persons, they, therefore, inhale a much greater quantity of oxygen gas, this decomposes and prepares the food for organization into the living mass much faster, and for this reason alone, a healthy child eats sometimes as much or more than an adult of four or six times his bulk, and grows, therefore, proportionably faster. This, too, is the reason why a child cannot bear the gnawings of hunger, and wants to eat oftener, and therefore, sometimes becomes a source of extreme annoyance to the careful and economical provider who does not understand the cause.

Owing to rapid breathing, "a bird, deprived of food, dies on the third day, while a serpent, with its sluggish respiration, can live without food three months, and longer," as has been proven by those enormous anacondas, who have swallowed deers whole, and then lain torpid for whole months, while the food is undergoing the slow process of digestion.

The reason why a laboring man requires more food, than one who does not labor at all, is this. His respiration is more rapid and the volume of air is greater at each respiration. The amount of oxygen, therefore, being greater, a larger amount of food is of course burned or decomposed by that oxygen, and so a greater amount is necessary to supply the exhaustion. It is worthy of remark, also, that the pulsations of the blood are proportionably quickened by the inspired oxygen, which shows that it imparts caloric or electricity to the fluid, in proportion as it is inhaled.

A thousand other facts upon this subject, respecting the reason why we require more food in the winter than in the summer—why the inhabitants of the polar regions eat more and heartier than those in the torrid—why a child requires more sleep than an adult and a laboring man than an idle one—why sedentary persons are simultaneously afflicted with the loss of appetite and a disinclination to sleep—and why the blood of a person is just as warm in Nova Zembla, as on the desert of Zahara, might be enumerated, until this fruitful subject alone should extend out into a volume. Our limits, however, forbid an extension. Suffice it, therefore, to remark, that all these facts and many others, which might be enumerated, result from certain invariable chemical changes wrought by the electric agent.

As, in another part of this lecture, we have given the phenomena of a diseased body, when minus, and suggested the appropriate remedies, we will now, for a moment, take into consideration one charged plus, or a person afflicted with a raging fever. Some of the symptoms are a flushed countenance, turgid veins, a parched tongue, a head ache owing to a rush of blood to that region, quickened and violent pulsation, rapid and labored breathing and a hot, dry, husky surface. And now what are the chemical causes and the appropriate chemical remedies for such a state of the system? Owing to a cold or some other cause, the natural, healthful perspiration of the body, by which a proper electrical condition expels certain impurities, is checked and entirely stopped by the closing of the pores.—The consequence is that those impurities enter in and derange the circulation, are carried by that circulation through the lungs and there come in contact with the oxygen. These impurities are burned fiercely by that agent, the heat enters into the system—both the pulsation and the respiration are quickened, this increases the amount of oxygen, until the blood is almost made to boil, and the difficulty is increased until the disease is either checked or else terminates in death.

Now what are the appropriate remedies for this plus condition of the system? Why evidently minus, cooling substances. The acids should be freely administered, and such alteratives as shall remove the cause, uncap the closed pores, make the impurities exude again in their accustomed channels, and thus prevent the oxygen from burning up the system by its fierce ignition of those impurities in the lungs. Those internal remedies should evidently be always aided by such external applications as are calculated to accomplish the object, such as bathing, and friction with such volatile liquids as will evapdly and cary off the surplus caloric, which have the tenden- in producing perspiration.

closing lecture of this series, we shall have occasion to w additional remarks upon this interesting subject, but feel- ; is imposible to do justice to it, in a work so limited, we soon as we shall have sufficient leisure, to publish a vol- ted entirely to the subject of animal electricity and electric

LECTURE IX.

SUBJECT—ELECTRO-MAGNETISM.

Among other important designs, it is our object, by the present course of lectures, to prove the identity of all the imponderables.—One very essential link in the chain of evidence will be furnished by the investigation of Electro-Magnetism. Until recently it was supposed to be an agent entirely distinct, and different from electricity. But it is now satisfactorily proven to be the same thing in essence.

This agent of nature was first discovered in a certain ore, found upon Mount Ida, in Asia, Minor, by one Magnes, a shepherd, from whose name the word *magnetism* is derived. This ore is called, by mineralogists, *magnetic iron ore*, or in common parlance, the loadstone.

The singular and wonderful powers which it exhibited in holding with considerable tenacity the various metals first led to its development. It was also ascertained that it would not only exert an invisible and unaccountable influence over metals, but that it would impart to steel permanently, the same kind of mysterious influence.

No wonder that this ore was regarded by some, as a talismanic or a magic rock, in the earlier ages, when the idea prevailed to a considerable extent, that unearthly beings could throw their spells of enchantment around substances.

It was next discovered, that if steel bars, which had been thus magnetised by the loadstone, were suspended at the centre by a thread or ballanced upon a pivot, they would invariably arrange themselves north and south. This led to the invention, as is supposed, by Flavio da Melfi, a Neapolitan, in thirteen hundred and two, of that important instrument, called the Mariners Compass, which opened a new era, in navigation. Mrs. Somerville, however, thinks different. She thus speaks in the following extract:

"The inventor of the mariner's compass, like most of the early benefactors of mankind, is unknown; it is even doubted which nation first made use of magnetic polarity to determine positions on the surface of the globe; but it is said that a rude form of the compass was invented in Upper Asia, and conveyed thence by the Tartars to China, where the Jesuit missionaries found traces of this instrument, having been employed as a guide to land travelers, in very remote antiquity. From that the compass spread over the east, and was imported into Europe by the *Crusaders*, and its construction improved by an artist of Amalfi, on the coast Calabria.—It seems that the Romans and Chinese only employed eight cardinal divisions, which the Germans successively bisected till there were thirty-two, and gave the points the names which they still bear."

Before this auspicious event, the wary seamen cautiously coasted along the shore, and dared not venture far from land upon the ocean, where the foaming waste of waters seemed to him an impassable barrier. But the compass changed the whole scene. With it the mariner fearlessly spread his canvass to the breezes, although assured that they would quickly hurry him away from the sight of his native shores and mountains. Guided by his faithful magnet, he left the coast, to which he had formerly clung so timidly, "*far—far behind him*," and sometimes held his onward course for weeks, and even months, through the wide waste of waters, without a glimpse of land to tell him where he was, and yet so perfect was that guidance, that, at any given moment, he could tell the latitude and longitude of the spot he occupied.

One important effect of that invention was the discovery of the happy country where we now dwell; for, had it not been for the unerring guidance of the magnet, through calm and through storm, Columbus, notwithstanding his skill in navigation, and the dauntless intrepidity of his character, could never have found his way across the ocean from Europe to Hispaniola.

The *cause* of magnetism was, for centuries after its discovery, enveloped in inscrutable mystery. But, by the recent experiments and investigations of philosophers, that mystery has been satisfactorily solved. About sixty years ago it was ascertained by the celebrated Beccaria, and by our sagacious countryman, Dr. Franklin, that steel and iron could be rendered magnetic by Electricity. Since then, by the conclusive experiments of Professor Oersted, of Copenhagen, Professor Moll, of Utrecht, M. De la Rive, of Geneva, M. Arago, of Paris, Dr. Wollaston, Sir Humphrey Davy, Mr. Faraday, Dr. Herschel, Mr. Christie, and many other philosophers of Europe, together with those of Professor Henry, Dr. Hare, Professor Silliman, and others of our own country, it has been demonstrated beyond the shadow of a reasonable doubt, that all magnetism is produced by Electricity.

Professor Oersted, in 1819, found, that, by passing a current of galvanism around iron of a certain quality, by means of insulated copper wire, it was made strong magnetic, and exhibited north and south polarity, one extremity of the iron attracting the north point of the needle, and the other the south. It was, also, ascertained that by passing a galvanic current around steel in the same way, it could be made permanently magnetic, the same as if rubbed upon the loadstone.

In the language of Mrs. Somerville, " very delicate experiments have shown that all bodies are more or less susceptible of magnetism

Many of the gems give signs of it; cobalt, titanium, and nickel sometimes even possess the properties of attraction and repulsion; but the magnetic agency is most powerfully developed in iron, and in that particular ore of iron called the load-stone, which consists of the protoxide and the peroxide of iron, together with small portions of silica and alumina. A metal is often susceptible of magnetism if it only contains the 130,000th part of its weight of iron, a quantity too small to be detected by any mechanical test.

"The bodies in question are naturally magnetic, but that property may be imparted by a variety of methods, as by friction with magnetic bodies, or juxtaposition to them, but none is more simple than percussion. A bar of hard steel, held in the direction of the dip, will become a magnet on receiving a few smart blows with a hammer on its upper extremity; and M. Hansteen has ascertained that every substance has magnetic poles when held in that position, whatever the materials may be of which it is composed."

It would be impossible, for the want of both time and room, to enter into a detail of the rise and progress of the science of magnetism, and trace the succession of various improvements made by the investigations of the learned. We must, therefore, content ourselves with a few brief remarks, in addition to what we have already said.

A variety of experiments have been made by many of the learned, at different intervals, "but the most astonishing, ever exhibited to the world in the production of magnetism by galvanic currents are those performed by Professor Henry, and Dr. Ten Eyck, of Albany, in 1831. They constructed a horse shoe magnet of Swedish iron, weighing sixty-nine and a half pounds, with an armature weighing twenty-three pounds. Around this magnet they wound twenty-six strands of copper bell wire, each thirty-one feet long, making eight hundred and six feet in the whole. About eighteen inches of the ends of the wire were left projecting, so that the aggregate length of the coils was seven hundred and twenty-eight feet. On connecting the wires with a battery of 4 7-9ths square feet, the magnet supported two thousand and sixty-three pounds. In one experiment with a smaller battery the armature continued to support more than one hundred and fifty pounds, three days after the battery had been excited.

From experiments already made, there seems to be no limit to the extent to which this wonderful power can be increased, by the increase of the size of the magnet, and the increase of the number of coils of wire.

How incomprehensible the force here exhibited—how disproportionate seems the cause to the effect! When the iron is bent, and wrought into its proper form, and wound with the requisite quantity of copper coils, it will not suspend a single ounce of itself. But just send a stream of electricity or galvanism around those coils, and, with its poles suspended downwards, it can be made to sustain four or five thousand pounds, without any visible chain of connection to hold the ponderous mass, and without having its own weight increased a single perceptible particle. This immense load is sustained there by no iron manacles—no hempen cord—hung there apparently upon nothing tangible, visible or corporeal—sustained by the simple unaided ligaments of cohesive attraction.—Who, after witnessing such an exhibition of incomprehensible force, who can doubt, for a moment, but that the powers of all other agents in nature are weak and impotent when compared with this. Who can doubt, for a moment, but that, if its almost omnipotent energies could be harnessed appropriately to machinery, by any invention, they would operate that machinery with a force as resistless as that exhibited by the bolt of heaven! Who can doubt but that its prodigious might is brought to bear upon the perfect machinery of the Universe and that it whirls the ponderous planets in their spheres and hurls the comet blazing through its lightning course.

Not only have magnets of great power been produced by electricity, but, quite recently, a surprising motive power has been developed upon a small scale. Miniature magnetic machines have been constructed, which would rotate upon their axis with a prodigious velocity, varying from five to fifteen hundred revolutions per minute, that being from three to five times as rapid as any revolutions produced by steam.

There have been invented two different kinds of electro-magnetic machines, the one operated by simple attraction, or by the influence of iron alternately magnetized and demagnetized by alternately breaking and closing the galvanic circuit, as it is called, and the other, by attraction and repulsion, or a change of polarity, which is effected by such an arrangement that the galvanic current circulates half the time around the magnet in one direction and the other half in an opposite direction, whereby the poles of the magnet change alternately from south to north, and from north to south, the polarity of the magnet being dependent upon the direction of the galvanic current around it.

Motion was produced, in 1830, by means of a galvanic magnet, constructed by Professor Henry, and so arranged, that it caused a beam suspended by its centre, to vibrate like the walking beam of a steam engine. Taking an idea from this invention of Henry's, similar machinery was constructed in Europe. Mr. McGauly, of Ireland reported, in 1835, a galvanic machine to the British association, and Mr. Sturgeon, of Woolwich, in England, gave a description, about the same time, of one, which he used upon his premises for pumping water, and for other mechanical purposes. But *rotary* motion was first produced by Dr. Edmonson, of Baltimore. In 1833, or 4, he constructed a very simple, but yet a very beautiful electro-magnetic machine, called *Edmonson's rotating armatures*, which was composed of a brass wheel, containing a small brass hub and an axle about four or five inches long, with six spokes of brass wire, an eighth of an inch in diameter, and six inches long, with soft iron armatures, composed of wire, a quarter of an inch in diameter, and two inches long, screwed upon the ends of the spokes, and arranged parallel with the axle. Through two brass pillars on each side of the wheel, which was horrizontal, passed two screws which formed pivots, upon which the wheel could revolve lightly and without much friction. At a little distance from one end of the axle was screwed a bass plate disc, about three inches in diameter, and, at the same distance from the other end, a serrated disc, containing as may points as there were spokes and armatures. These revolved in cups arranged underneath, containing mercury. On the outside of the whole was placed a single electro-magnet of small size, which, when charged with a small battery, would attract the soft iron armatures successively toward itself, until they came to the point, where it would hold the iron and prevent motion, were it not so arranged, that the movement of the wheel would demagnetise the magnet, by lifting the point of the serrated disc out of the cup of mercury, and thus by breaking the circuit, explode the magnetism in a brilliant galvanic spark and let the armature pass by. This wheel could be made to revolve from three to five hundred revolutions per minute.

Although it has been generally supposed that Davenport, first produced rotary motion, by means of magnetism, yet this honor, as we have shown, belongs to another, who invented his rotating armatures about three years before Mr Davenport perfected his electro-magnetic machines.

These rotating armatures of Edmonson are moved by simple atttraction. But to Davenport belongs, however, the exclusive honor of inventing a machine moved by alternate attraction and repulsion, which, for a time, astonished the whole scientific world, and inspired the general belief, that the power of electro-magnetism was about to be brought to bear upon machinery.

A brief detail of the several stages of progression, by which Davenport perfected his invention, and discovered truths which had, for ages, eluded the keen sightedness of the scientific, would doubtless, be interesting to those who are unacquainted with the facts.

Mr. Thomas Davenport was an unlettered blacksmith, of Brandon, Rutland county, Vermont. In the course of his trade, he went, in 1833, to the Penfield iron works, at Crown Point, on Lake Champlain, to purchase iron. His curiosity was there very much excited by the operation of a revolving machine with several hundred magnetised steel points or teeth, which passed through pulverized ore, to separate the particles of iron from the surrounding material. Finding, upon enquiry, that these points were magnetised by a small electro-magnet, weighing about four pounds, he enquired the price of the apparatus, and, instead of purchasing iron as he contemplated, he expended his money for the magnet and took it home. Filled with that kind of enthusiasm, which completely absorbs some minds, and which appears superlative folly, and mental hallucination to those dull phlegmatics, who always plod along in the beaten path of grandfathers and great grandfathers, he commenced a series of experiments with his magnet, assuring his neighbors and friends, that it was his firm belief, that this power could be made to propel the largest boats. Although this announcement was received by them with general incredulity and ridicule, and although he had to encounter every discouragement on account of deficiency in his pecuniary resources, and the continual dissuasion of his acquaintances, he pressed forward with a commendable and indomitable perseverance toward the accomplishment of his object.

It is proved by all history, that a mind, which is truly inventive, and capable of conceiving grand projects, has the dignity to rise above the influence of both sneers and dissuasions, and to accomplish such projects, if they be within they range of possibility. Such was the mind of Thomas Davenport. He was neither discouraged nor disappointed by the reception he experienced. "He thought and reasoned for himself; and, relinquishing his trade, he devoted his undivided attention to the object in view. After trying hundreds of experiments, and devoting several months to an intensity of reflection, which would have brought many others to a lunatic asylum, he finally, in July 1834, accomplished the arduous task of bringing the invisible and mysterious power of magnetism into subjection. A power which, 'steady as the needle to the pole,' had been thought the most unyielding of all others: forming an arrangement by which this very polarity, this steadiness of purpose, is made to produce rotary motion."

After encountering many hindrances, Davenport perfected, so far as it was possible to perfect, his miniatures machines, so that they would revolve with almost inconceivable velocity. They consisted, sometimes, of both stationary and revolving magnets, so arranged, that, by their movements, the polarity of the magnets would instantaneously change at a certain point, and thus the machines would be alternately propelled by attraction and repulsion, resulting from a change of that polarity.

As it would, by mere language, without the apparatus, be impossible to give such a description of the machinery, as to convey a clear idea of the precise manner of its arrangement, (by which polarity is changed during revolution,) to the minds of those, who have never seen it operate, and, as it would be unnecessary to give such a description for the satisfaction of those, who have seen it operate, we shall omit it altogether.

After having perfected his machines upon a small scale, so that they performed admirably, he proceeded to construct one upon a larger scale, for the purpose of acquiring power if possible. But in this experiment, he was unsuccessful, and the persevering origitor of a wonderful invention has passed into obscurity again, like lashing meteor, and is now almost forgotten.

When he proceeded to enlarge his machinery, he met with an unex- ected and insurmountable difficulty, in the impossibility of so nicely ranging it, that the polarity would change perfectly, at the proper int and time, and the one force give place completely to the other. here would, on the contrary, be, at that point, a contention be- reen the two powers of attraction and repulsion, which contention ould neutralize the power of the two, and bring the machine to a and.

While investigating, in 1838, this interesting subject, we were isfied, that machines, operated by a change of polarity, could nev- r be any thing but mere philosophical toys, interesting and won- erful, but entirely useless. It occurred to us, however, that the ifficulty could be obviated by machines operated by simple attrac- on, provided that there could be an arrangement made, by which e power, should be kept up without intermission. This we effec d, by bringing a series of magnets to bear upon the same wheel, such a manner, that, by means of non conductors between the ser- ted discs, by which the galvanic circuit was broken, one circle of e series should be charged, while another was demagnetised, and the power continued without intermission. Having been quite ccessful, in the first model constructed, we sent a description of e same to the Patent Office at Washington in 1838, designing at the me to have taken out a patent and to have tested the invention up- a large scale, but other engagements have prevented the contem- ated experiment.

As far as this mysterious and wonderful motive power has been plied. It can be regarded only as a most interesting philosophical y. But the question here occurs—can it be applied to any prac- al purpose—can machinery, upon a large scale, where great re- stance is to be overcome, be propelled by it? This remains to be proven. We are not prepared to say that it *cannot*, nor are we prepared to say that it *can*. Of one thing we have a practical demonstration, It operates well upon a small scale, and exhibits considerable force. Whether it will upon a large scale depends upon the developements of futurity.

Rotary motion was produced by steam, fifty years before it was applied to any practical or useful purpose. Its minature machinery was then looked upon as an interesting philosophical plaything, as electro-magnetic machinery now is. It has been only about ten years since the motive power of magnetism on a small scale was developed, and it would be forming a conclusion with more dogmatic positiveness than we are willing to form one, to hazzard the assertion, that loco motives may not, within fifty, nay, within twenty years be driven with lightning speed over our rail roads, by magnetism, and the electric boat, instead of the steam boat, he propelled across the Atlantic. There are a thousand improvements yet to be made, which have not even been *dreamed* of, by the most acute philosophers. Some Davenport may even now be perfecting machinery, which may, by its successful operation, astonish the world as much as the motive power of magnetism did, when first developed. There is certainly, no lack of energy in the agent. Its inherent force surpasses steam, or any other naturl agent. There is a superbundance of power, as is demonstrated by the magnet of Professor Henry. Its correct application is all that is needed, and we are, by no means, prepared to say that such an application cannot be made. From what we have seen, we are rather inclined to believe that it can, and that it will, althought the person, who is hardy enough to persevere, may encounter as many sneers as the immortal Robert Fulton did, before he succeeded in applying steam power to navigation.

We will close this lecture by remarking, that, as our object is to prove the identity of all the imponderables, and that they are elec-ricity, magnetism aids materially to demonstrate this, from the act that a galvanic current will make a magnet, and out of magnets an be drawn both electric sparks, and electric shocks, as in the op-ration of the magneto-electric machine.

LECTURE X.

SUBJECT—LIGHT.

HAVING examined the subject of common Electricity, Galvanism, Magnetism, and other kindred subjects, and proved their identity, and demonstrated that this indivisible, imponderable principle is the wondrous agent, by which *all chemical changes* are effected, we shall now endeavor, by a formidable array of facts, and by conclusions drawn legitimately from them, to prove that the sun is the SOURCE of this agent. This will require us, in the first place, to investig ate the *properties of Solar Light*.

This, *it is evident*, is to be regarded as the founain, from which continually flows all natural light, for, it will appear conclusively in the course of our observations, that it would be utterly impossible to produce fire were it not for the existence of this agent. And here an interesting question respecting its nature and essential properties *forcibly* suggests itself to the mind:— What is that light? It seems to be a subtle, ethereal, all pervading fluid. No sooner does it glance upon a substance than it is gone. Suddenly darken a room into which a strong flood of light is pouring, and it is all dissipated as instantaneously as thought. Not a solitary ray is left to illuminate the darkness. Blow out a candle, whose light can be seen by the eye, at any point for a mile in every direction around it, and which, therefore, completely fills several cubic miles of space, and not the minutest iota of time does that light continue, after the candle is exguished. A thunder bolt blazes across the black canopy of a idnight of storm, and its scathing light fills perhaps a thousand cu- c miles of space. Blinded by the intense and lurid glare, the eye the beholder shuts for an instant, and opens—upon what?—A dark- ss deeper, if possible, by contrast, than before. The lurid flash has ome.—Where? Is it annihilated? No. It is somewhere in a ate of diffusion, and consequent invisibility, and if collected under e same circumstances, it would exhibit the same flash as before, nd again diffuses itself through the mass of surounding substances. ight, then, as we have already remarked, is subtle, etherial and ll-pervading.

It is imponderable too—that is, it can be neither weighed nor easured. When a ponderable substance of several tons bulk, is ompletely saturated with it, the specific gravity of that substance is ot increased the smallest perceptible particle.

Never, for an instant, is this subtle agent stationary. The lightning peed of its everlasting career can be compared with no other agent n nature except Electricity. It glances quick as thought from heav- n to earth—from the sun to the planets.

There are two theories respecting the substance or essentiality of ight, both of which will, for a moment, be examined. Dr Herschel and is coadjutors supposed that it was the effect of the undulation or vibra- ion of a subtle, etherial medium every where present in nature, and hat it is transmitted to the eye the same as sound is to the ear. Up- his hypothesis there would be no direct communication between he sun and the earth, or the other attendant planets, and this being he case, the generally received opinion among philosophers, that he movements of the planets are governed by a certain kind of in- luence exerted by the sun over them, would be erroneous; for we old it to be a truth capable of the clearest and most logical demon- tration, that there cannot be any influence exerted by one substance ver another, without a direct and a positive connection, of some sort between those two substances. To suppose the contrary, would be to suppose that there is a connection, and that there is not a connection in the same breath, which is a self evident contradiction in terms. We hold such an influence, without such an actual connection, to be an impossibility in the nature of things, which, to speak reverentially, not even omnipotence can overcome, for God himself never claims to do that which is an imposibility in the nature of things. But it may be said that the Almighty created the universe with a word and that there is no positive connection between a mere word and such a stupendous effect. True, but if he created that universe with a word, his all pervading Omnipotence was present to give that word efficiency; for to suppose the contrary, would be to suppose that God can withdraw himself from a positive connection with his own agencies, which is another self evident contradiction, unless you can undeify the Deity and make infinity finite.]

Besides, the opinions of Dr. Herschel, upon this subject are unphilosophical and contrary to known facts. Instead of undulating or vibrating, light moves in direct lines. This is capable of positive proof. The angle of incidence and that of reflection are the same. Let a stream of light fall upon a mirror at a particular angle, and it will be reflected from that mirror in an exactly an opposite angle.—It is a tested and acknowledged fact, also, that light will not pass through a bent tube. But if it moved in undulations or vibrations like sound, this would not be the case, for sound *will* pass through such a tube. These facts and arguments, therefore, prove that the hypothesis of Dr. Herschel, respecting light, is false and unphilosophical.

The other theory, of which we spoke, is that of Sir Isaac Newton. It was the opinion of that great philosopher, that solar light is an infinitesimal effluvia of matter or an emanation of inconceivably minute particles flying off from the body of the sun, and darting in straight lines through that space which is occupied by those opaque bodies are governed by its influences. This hypothesis we consider orrect and philosophical, if we regard it as an emanation of , different in its nature and essential properties from ponderart matter—if we regard it as an imponderable essence, as it ass is, governed by the very same laws, and exerting precisely ae agencies as the other imponderables, which we have already ed. Newton, however, left some things unexplained in his of solar emanation, which, unless satisfactorily accounted for, involve the subject in an inexplicable difficulty. Although he ined the opinion that light was constituted by a flight of partim the sun, and thus far was doubtless correct, yet he neglecfailed to account for the supply of that waste of the substance un, which must unavoidably be the consequence. The obto his theory, who might wish to puzzle the philosopher, might question, "If light be an emanation of infinitesimal atoms icles of matter from the orb of day, why is it not diminished— t exhausted and blotted out?" And such a question too would ery natural one, and deserving of attentive consideration.— s constantly emanating from the Sun. This is a known and ally acknowledged fact in science. Every conceivable point e for ninety-five millions of miles around that luminary to the of our earth, and so around the whole circumference of that constantly filled with this light; and as light is estimated to om the sun to the earth in eight minutes, then this whole ean of light, one hundred and eighty millions of miles in diamd nearly five hundred and forty millions of miles in circumferontaining billions upon billions of cubic miles of light diffused pace, is displaced every eight minutes by a new emanation—a ocean of light, and that by the flood-tides of another ocean, and another, and so on to infinity.

is this all. The whole space between us and the far off Herschel is thus constantly filled with light, and that light, is thus constantly displaced, by wave succeeding wave in endless succession.

Now the idea that this is matter which is thus passing off from the sun with the glance of the lightning-flash, and filling every eight minutes an almost inconceivable area of space, would be preposterous in the extreme, unless there were, by some process of nature, an adequate supply for such an immense and unavoidable waste. This conclusion is in strict accordance with every principle of philosophy, analogy and fact It is perfectly evident that particles flying off from a body must inevitably diminish that body. No matter how infintitesimally minute those particles, nor how immensely large the substance, this must be the case, so long as the smallest atom of matter conceivable possesses both length, breadth and thickness.

It can, then, be mathematically demonstrated, as perfectly as any problem of Euclid ever was, that the sun, unsupplied from some source, would, long since, have been frittered away by infinitesimal abstractions, and been utterly annihilated by this waste, even though we should, for the sake of argument, adopt the supposition, that a million of cubic acres of those particles, when condensed sufficiently, should weigh no more than the ten thousandth part of a single grain; for, however, vast in magaitude be the substance, such a dimunition as must take place by an emanation of particles so immense as to fill a cubic bulk of space one hundred and eighty millions of miles in miles in diameter, and nearly five hundred and forty millions of miles in circumference every eight minutes, must certainly annihilate that substance completely in process of time. As "a continual dropping wears away the solid rock," so a continual waste must eventually exhaust—completely and utterly exhaust even the bulkiest mass conceivable

If light then, be the emenation of infinitetsimal effluvia from the sun, as it doubtless is, how shall we rescue the Newtonian theory from the difficulties in which it seems to be involved? We must suppose r that there is, somehow, an unseen and imperceptible return of ; particles, to the source from whence they emanated, or that great fount of light is constantly fed by creative agency con-tly exerted, or else, as the horrid alternative, that the world ld long since have realized the terrific phantasies of Byron's po-dream on darkness, when—

'The bright sun was extinguished. and the stars
'Did wander darkling in the eternal space,
'Rayless and pathless, and the icy earth
"Swung blind and blackning in the moonless air."

he latter alternative, we know, however, has not taken place, the proposition, that the waste is supplied by direct creative agen-is contrary to all the analogies of divine economy. When the ighty created the universe, he created, also, it is presumed, all natural laws and agencies by which that universe should be gov-d, until the present order of things shall be broken up by the e Omnipotent word and energy which established it and,

"Final ruin fiercely drive her ploughshare o'er creation.'

lid not leave his work half done. He completed creation—he iounced the whole good, very good, and on the seventh day he d from his labor. It cannot be presumed that the process of ting new materials to supply any deficiency in this splendid ma-ery of worlds is now progressing. The supposition would be gatory to the skill of the great architect. It would be contrary e analogy of all his doings. Although there are continual chang-ing forward in the materials of which this globe and its surround-.tmosphere is constructed—although there be a ceaseless pro-sion of chemical decomposition and recomposition among vari-substances—although what was a tree, one year, may, by trans-ation, become glass the next—or what was grass one day may me either flesh or milk or cheese or butter the next—or what was in one age may be petrified into limestone the next, and of floating in the water. become the material with which your parlors are plastered. yet, it is presumed, that not a single new particle has been added to the globe or its varied furniture since creation, however modified it may have been, either by nature or art. One might imagine, perhaps, that, in the combustion of fuel, there is some destruction of material. But such is not the fact. It has only undergone a change. Every particle of it exists some where either in vapour or smoke or the gasses or in ashes. And so with every thing else. When the streams dry up in the season of droughth, there is not a drop the less water than before. It is either in the deep well springs of the earth, or is borne about in the vapours of the atmosphere, nor is there a drop more when the streams are full, nor was there, when the windows of heaven were opened, and the fountains of the great deep were broken up, and the deluge covered fifteen fathoms deep, the tops of the highest mountains. It was either spouted up from the subterraneous reservoirs of earth, or the surrounding atmosphere, which extends forty five miles above the globe gave out its watery treasures, or the melted icebergs came down in torrents from the arctic and antarctic seas.

From these analogies, and a thousand others unmentioned, we infer that no creation of material is progressing to supply the waste of the sun. Shall we then resort to the other hypothesis, that the otherwise unavoidable diminution of the sun is supplied by the return, through some channel, of those same particles, which have accomplished the object of their mission? Let us see what testimony analogy furnishes upon this important subject, before we hazzard an answer. The human body affords a good illustration. The heart sends out the vital stream by successive pulsations, through its purple channels, to the extremeties, of the system, and is, in its turn, supplied by that same blood, which it sent out in its passage back through the little veins, to be again projected by the self moved motion of the wondrous machine.

The waters of the globe afford another very good illustration.—The ocean is, as it were, the heart of the earth. By evaporation it supplies the clouds with water, this is borne over the globe and discharged among the mountainous regions, to supply the high lakes and fountains. These send forth the little rills and streams, which, uniting in their course, form rivers, which empty into the ocean again and keep that immense reservoir unexhausted. Now, what the heart is to the human body, or the ocean to the globe. I conceive the sun to be to the solar system. By its mighty pulsations, it sends out its living stream to vitalize and energise creation, and when one pulsation has done its work, and given its share of the mantling blush of health to the cheek of beauty, and of luxuriance to the verdure of vegetation, and of varied tints to the flower, and of ripeness to the mellow fruits, and of motion to the planets, it speeds on in its lightning circuit, and gives place to another pulsation, and thus pulsation after pulsation chase each other in one interminable and ceaseless round, supplying by some inexplicable method of return, the waste which must otherwise accrue.

We have considered the Newtonian Theory of the materiality of light as correct, though not matter in the common acceptation of the term, for it is totally different from any tangible, appreciable form of matter, with which we are acquainted—being imponderable, and immeasurable, passing through transparent mediums without seeming to encounter any obstacle—entering readily into the eye, the tenderest and most delicate organ, without causing pain or being perceptible in its passage. The following appropriate extract from Fergusons Astronomy will forcibly illustrate the extreme subtlety and imponderability of this agent. "Light consists of exceeding small particles of matter issuing from a luminous body; as from a lighted candle such particles of matter constantly flow in all directions. Dr. NIEWENTYT* computes, that in one second of time there flows 418,660,000,000,000,000,000,000,000,000.000,000,000.000,000 particles of light out of a burning candle; which number contains at least 6,337, 242,000,000 times the number of grains of sand in the whole Earth, supposing 100 grains of sand to be equal in length to an inch, and consequently, every cubic inch of the Earth to contain one million of such grains.

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* Religious Philosopher, Vol. III. p. 65.

These amazingly small particles, by striking upon our eyes, excite in our minds the idea of light; and, if they were as large as the smallest particles of matter discernible by our best microscopes, instead of being serviceable to us, they would soon deprive us of sight by the force arising from their immense velocity, which is above 164 thousand miles every second*, or 1, 230,000 times swifter than the motion of a cannon-bullet. And therefore, if the particles of light were so large, that a million of them were equal in bulk to an ordinary grain of sand, we durst no more open our eyes to the light, than suffer sand to be be shot point blank against them."

Now, with respect to extreme subtlety, does not light resemble electricity. Is there any other agent in nature, which will pass thus through the eye without affecting it except electricity, for that will thus pass. Let a pointed rod be connected with an electric machine, and a stream projected through the eye from that point will cause no more pain than light—, though differently modified. And if light be electricity, there would then be an additional argument in favor of the supposition, that emanations of this fluid return again to their source, the sun, as all electricity, however modified, moves in a circuit, and exhibits no effect except the circuit is closed.

This is doubtless a novel idea, and may, for that reason alone, be considered, at first thought, chimerical and baseless. But we only ask calm reflection upon the subject, and candid attention to it, for, we are persuaded, that, after mature consideration, it will not appear so visionary, as may, at first glance, be supposed. If it perform a circuit, it must be so immense, as to be almost beyond computation. To illustrate this subject, trace a single ray, for instance, in its passage from the sun, out into space, for millions upon millions of miles, and there would be a point in its outward passage, and its consequent continual divergence, that the ultimate particles, which constituted that ray, must of necessity begin to separate from each other.—Now, when they come to that point of incipient separation, what becomes of them? If they make a complete circuit, as we believe they do, the ultimate particles, which composed the ray, would, when they began to separate, (if they have the same organic laws as electricity, which we shall prove.) present their negative or minus polarity toward the sun, and, in that separated state, they would be drawn back to their source by the simple laws of the attraction of opposite polarities, which we have already abundantly demonstrated.

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* This will be demonstrated, in the eleventh Chapter.

But it may be affirmed that, as light moves in straight lines, one part of our theory clashes with another, since, according to this view of the subject, it must move in *curved* lines. This apparent clashing, however, is very easily explained, and this objection readily obviated. So inconceivably immense is that orbit, which is described by a ray, that, although it is *actually* circular, yet any perceptible part of the orbit, which it describes, would appear to be *straight* to us, and thus there be no clashing between the two positions in reality.

It would be very easy, we are aware for a fruitful imagination to invent objections, but before our conclusions be confidently and positively denied, we would ask those, who would invent such objections, to tell us what becomes of light, if it does not thus move in a circuit and thus return to its source. Is it annihilated, or does it become stagnated and dormant and lose its inherent activity in the vast abyss of space? And if it move not thus, and return, we would ask those, who invent such objections, if they are prepared, in any other plausible or rational way, to account for the otherwise una-

[illegible] of the material of the sun. If they can, we will willi- [illegible] however, and will pledge ourselves to give up all pre- [illegible] in favor of any opinion which we may have harbored.— [illegible] cannot, they are bound, we think, to consider well the [illegible] of making objections upon a subject, when they know not positively whether their objections are well founded. Firmly believing, however, that they cannot, we shall, for the present, at least, adhere to the conclusions to which we have already come.

Light then doubtless, after having performed its office returns to [illegible] and thus closes its circuit. Else, what, I ask, becomes [illegible]! Has the earth, for instance drank in and retained all the light [illegible] has been shed upon it by the sun since creation? If it had we conceive it to be a proposition capable of the clearest demonstration, that it would have been, by this time, a complete ball of light like the sun. Besides had it retained all the rays which have fallen upon it since the morning of time, its bulk ere this, would have been very sensibly increased; for, although light be imponderable, yet it is something, and is capable of accumulation, like other matter, if retained. Not only would the earth be increased by this accumulation, but every planet of the solar system, and the sun, as every one must see, would be proportionably diminished. And what would be the consequence of such a dimunition of the one, and increase of the others! Why, the perfect balance of the system, which produces such a wonderful regularity of revolution, that eclipses can be foretold, for years before their occurrence, to the definiteness of a single moment, would be entirely destroyed, and the whole would rush headlong to the confusion and darknes of chaos. Neither the earth, [illegible], nor the other bodies of the solar system have retained the the light, which has fallen upon them, but having been as completely [illegible] the first twenty four hours of their existence as ever, they [illegible] of all superabundance, the same as substances do, when

We have dwelt upon this subject of the return of particles to the sun with the more minuteness, because, if true, it may account satisfactorily for an important phenomenon, to which we shall have occasion to advert hereafter.

We shall defer until our next lecture, the further consideration of this important and interesting subject, and hope, by still further argument, and proof, to demonstrate the correctness of our position.

LECTURE XI.

SUBJECT—LIGHT—HEAT.

The commencement of the present lecture will be the continuation of the subject of the identity of solar light and electricity. In the discussion of the subject, such a chain of proof will, we think be linked together, as to be conclusive and irresistibly convincing. As the correctness of our theory depends mainly upon the demonstration of the proposition that light is electricity, we will proceed in the examination proofs. The two possess many properties in common. Light, generally speaking is attended with heat—so is electricity. Light has inconceivable rapidity of motion—so has electricity. The one is imponderable, immeasurable, all-pervading —equally so is the other. And what if they do vary in some of their appearances—vary in some of their effects and operations? Does that circumstance necessarily destroy their identity—their oneness in principle or in essence? Certainly not. Known and acknowledged electricities thus vary, and that too, quite as widely. The spark and the shock of the electric machine are somewhat different from the galvanic current. The metoric shower is different from the keen flash and fierce energy of the bursting thunderbolt. The blaze of the the thunderbolt is different from the mysterious corruscations of the Aurora Borealis and Aurora Australis, and these again are all different from magnetism or magneto-electricity.— Even the very same galvanic current, when modified by machinery as can be demonstrated with a piece of apparatus, is different under one set of circumstances, from what it is under another. If a person take hold of the poles of a small battery, and close the circuit, he receives no shock. But pass that same current around a helix of copper wire, enclosing soft iron, and forming what is called the magneto-electric machine, and then, by the action of the machine, a person receives shocks whenever he closes the circuit, by taking hold of tin tubes having a connection by conducting wires with the positive and negative poles of the helix. This proves *conclusively* that dissimilarity in appearance or in action destroy not identity or oneness in principle or in essence. This dissimilarity depends on modification and on that alone, the causes of which are, sometimes, apparent, and sometimes latent. The want then, of resemblance in any respect between light and electricity, destroys not necessarily their identity. And even on the score of similarity, they are, by no means, materially deficient. There are, in fact more points of marked resemblance between them, than between many known and acknowledged electricities—more, for instance, than between the Aurora Borealis and magnetism. And were the attention of philosophers and chemists turned to the investigation of this subject with all that intensity, which its importance demands, we are persuaded, that more resemblances still would be discovered. Who can tell, but that, if, by any means, an immense number of rays could be brought together into one line of light, as they are brought to a focus by the lens or burning glass, and could they be continued onward in that line, without being scattered—who can tell, we say, but that this condensation of rays might be one continual stream of fire, like that of the electric fluid ?

But a truce to supposition. We need not resort to hypothesis or conjectures to establish the plausibility, or even the logical *certainty* of our argument. We appeal to facts—*incontrovertible* facts, to prove that light is electricity. These facts we shall glean from the observations of practical men, which are preferable to any philosophical surmises or fine spun speculations.

Lieutenant Johnson, of the British navy, often noticed that a considerable variation of the needle of the compass was produced by the rays of the sun falling upon the glass which covers it.

In support of this testimony, I have that of Mr. Harris, a resident of Ravenna, Portage county Ohio, who had been a surveyor at the West more than twenty years, and who had often been engaged in running lines. In the commencement of his business, he was often much troubled by the variation of the needle, and imputed it, at first, to the vicinity of iron ore, which is the popular solution generally given for such phenomena. But he noticed, after a while, that those variations occurred in a cloudless day, and just about noon, when the sun was vertical. The idea occurred to him, that it might be electricity, produced upon the glass cover by the suns rays. In order to test the correctness of that idea, when such variations occurred, he moistened the glass so as to disipate the electricity, and found by so doing, that the variation was instantly prevented.—Since that, he affirms that he has been no more troubled with the supposed attraction of metalic substances, and his remedy is an infallible preventive of the variations that so much troubled him.

Since we first commenced the particular investigation of this subject, in 1838, we have had frequent opportunities to consult the oldest and most observing practical surveyors, and they have, without an exception, in every instance, corroborated the statements of Mr. Harris, and Lieutenant Johnson. One whose name, for particular considerations, we shall omit, but who was as good authority, probably, as any one we have consulted, not only testified his firm belief in the cause assigned by Mr. Harris, but, suggested the thought, that both diurnal and annual variations of the needle might, possibly, be determined by the variations even of the thermometer.

But some may, perhaps, be willing to acknowledge the premises, from which we started, but deny the validity of our conclusions.—They may assent to the proposition, that electricity causes such variations of the needle, as we have been contemplating, and that that electricity may be produced by the mere friction of the suns rays upon the glass cover of the compass, but, that it cannot be the sun-light itself. This, however, would be an assmption altogether unreasonable and unphilosophical. Even if produced by the friction of the rays, (which cannot be the case, since light passes so readily through a transparent medium, without friction,) either the light or the glass must give out the electricity; for, in all cases, where electaicity is developed by friction, either the rubber or substance rubbed produces it. The one substance, that affects the other, is, uniformly, the substance that is the generating agent. Even if light, then, produces electricity by friction upon the cover, it, after all, developes it from its own substance, and so, nothing is gained by the objector, nor are our conclusions at all impaired.

In addition to these facts, which are, of themselves, sufficient to demonstrate that light is electricity, it has been ascertained by the celebrated Mrs. Somerville, of England, that by passing the suns rays thro' a prism, and separating them, by analyzation, into the seven primitive colors, the blue color possesses the power of imparting magnetism or polarity to the needle, and *magnetism*, we now know, to be electricity by experiments too conclusive to be controverted.

There is another very important fact respecting the organic laws of the constitution of both light and electricity, which furnish additional and weighty testimony in favor of identity. The attractions of electricity decrease in exact proportion as the squares of the distance increase, in receding from an electrified body. This is precisely, (as we should suppose,) the law of the divergence of light, and this law, which runs throughout all the imponderables, has its origin in the law of solar emanation or divergence, and the simple reason why the attraction of all bodies decreases in proportion, as the squares of the distance increase, is because the emanating influence of all bodies, which constitutes attraction, obeys this law.

The very strongest testimony, however, in proof of our proposition, is contained in the phenomena of the polarization of light, by which it is *demonstrated*, that every particle of light, as well as of electricity, *has opposite polarities*. This curious subject will be more fully examined, when we come to the discussion of the subject of caloric.

By a fair logical deduction, then, with facts amply to sustain it, we, unhesitatingly infer that *light is electricity*.

Heat or caloric comes next in the order of remark, and, in the investigation of this subject we shall accumulate such an additional array of facts as shall establish our proposition beyond the shadow of a doubt.

The same arguments which would prove that light is an electric fluid are applicable, also, to the agent of heat. Heat like light is imponderable, subtle, etherial and all-prevading. No obstacle can stay its *passage*. It insinuates itself between the particles of the densest bodies as though it were immaterial. Its power is prodigious—irresistible in its energies. It generates the tremendous power that propels the steam boat; and were it, or could it, by any means, be confined in subterraneous volcanic caverns with bands strong enough, and there accumulated, it would, by the power of its expansive and explosive force, burst the solid globe to atoms, and send its shattered fragments in every direction through the vacuum that surrounds it.

With a glass bulb and tube, for instance, one of the energies of heat, can be forcibly demonstrated. By inverting it, and inserting the open end in a basin of water in its natural state, you will perceive no effect whatever. But, by passing into the tube the subtle agent of caloric from a spirit lamp, and again inverting it, you will see the water rise with great rapidity, and fill more than nineteen twentieths of the tube. This shows that heat has the power to expel the atmosphere and occupy its stead. But the moment you attempt to confine it there, by closing the tube, it is gone, like a flash—gone like a viewless, incorporeal, intangible thing, and the water rushes up to fill that vacuum.

If all the imponderables, as we have assumed, be identical, then Light and Heat are the same—they coexist and are inseparable.—But, it many occur to some one, that those phosphorescent substances, which emit light, do not, also, emit heat, and that our position is, therefore, untenable. This conclusion is, however, altogether too hastily formed. It will be seen, by the following lucid extract from Turner, that heat is *always* necessary to make substances phosphorescent.

"The chemical agency of artificial light is analogous to that from the sun. In general the former is too feeble for producing any visible effect; but light of considerable intensity, such as that from ignited lime, darkens chloride of silver, and seems capable of exerting the same chemical agencies as solar light, though in a degree proportionate to its inferior brilliancy.

Light is emitted by some substances, either at common temperatures, or at a degree of heat disproportioned to the effect, giving rise to an appearance which is called phosphorescence. This is exemplified by a composition termed Canton's phosphorus, made by mixing three parts of calcined oyster-shellss with one of the flowers of sulphur, and exposing the mixture for an hour to a strong heat in a covered crucible. The same property is possessed by chloride of calcium (Homberg's phosphorus,) anhydrous nitrate of lime (Baldwins's phosphorus,) some carbonates and sulphates of baryta, strontia, and lime, the diamond, some varieties of fluor-spar called chlorophane, apatite, boracic acid, borax, sulphate of potassa, sea-salt, and by many other substances. Scarcely any of these phosphori act unless they they have been previously exposed to light; for some, diffused day-light or even lamp-light will suffice; while others require the direct solar light, or the light of an electric discharge. Exposure for a few seconds to sunshine, enables Canton's phosphorus to emit light visible in a dark room for several hours afterwards. Warmth increases the intensity of light, or will renew it after it has ceased; but it diminishes the duration. When the phosphorescence has ceased it may be restored, and in general for any number of times, by renewed exposure to sunshine; and the same effect may be produced by passing electric discharges through the phophorus. Some phosphori, as apatite and chlorophane, do not shine until they are gently heated; and yet, if exposed to a red heat, they lose the property so entirely, that exposure to solar light does not restore it. Mr. Pearsall has remarked that in these minerals the phosphorescence, destroyed by heat, is restored by electric discharges; that specimens of fluor-spar, not naturally phosphorescent, may be rendered so by electricity; and that this agent exalts the energy of natural phosphori in a very remarkable degree. The theory of these phenomena, like that of light itself, is very obscure. They have been attributed to direct absorption of light, and its subsequent evolution; but the fact, that the color of the light emitted is more dependent on the nature of the phosphorescent body, than on the color of the light to which it was exposed, seems inconsistent with this explanation. Chemical action is not connected with the phenomena; for the phosphori shine in vacuo, and in gases which do not act on them, and some even under water.

Another kind of phosphorescence is observable in some bodies when strongly heated. A piece of lime, for example, heated to a degree, which would only make other bodies red, emits a brilliant white light of such intensity, that the eye cannot support its impression.

A third species of phosphorescence is observed in the bodies of some animals, either in the dead or living state. Some marine animals, and particularly fish, possess it in a remarkable degree. It may be witnessed in the body of the herring, which begins to phosphoresce a day or two, after death, and before any visible sign of putrefaction has set in. Sea-water is capable of dissolving the luminous matter ; and it is probably from this cause that the waters of the ocean sometimes appear luminous at night when agitated.—This appearance is also ascribed to the presence of certain animalcules, which, like the glow-worm of this country, or the fire-fly of of the West Indies. are naturally phosphorescent. "

Light and heat, then, we regard as the same thing. They coexist and are inseparable. All the percep tible difference between them, consists in volume or degree, and in volume or degree *alone*, and not in nature. Light exists either *radiant* or in a state of *diffusion*, and, consequently, *latent*. It is *radiant* when coming from the sun to the earth, but the moment it strikes the earth, it becomes latent, but it is still *light*, just as much, though not seen, as it was before, and, could it be condensed into the same compass, and under the same circumstances as before, it would become just as radiant as before.

Heat is only light in a state of diffusion, as we before remarked.—This is proven by the fact, that, if you condense it sufficiently, you make it light. Take a piece of iron, for instance, and heat it to a certain point, and it is still latent, or invisible, but condense a trifle more heat, upon the iron, and it begins to be light—condense more still and it grows lighter and so continue and you make it glow, at length, with a radiance almost as intense as that of the sun at noonday. but still it is only heat. Light, then, is only heat *condensed*, and, the more it is condensed, the more intense is that radiance ; and, on the other hand, heat when latent, or invisible, is light in a state of diffusion. All the difference, then, between the two, is in volume or degree, and in volume or degree *alone*.

The same remarks apply with equal force to electricity. When condensed in the electric spark, or in the galvanic current, or in the blazing thunderbolt, it is *radiant* electricity, but, when not condensed, it is *latent* electricity, or electricity in a state of diffusion and invisibility. But. whether radiant or latent, it is the same thing, precisely, only accumulated in different volumes.

Some suppose, that, when the electric spark, or the thunderbolt explodes, the electricity is destroyed. That, however, is an erroneous supposition, as can be proven by experiment. It only passes into a state of diffusion, and consequent invisibility, but is essentially the same thing as before, and, could it be collected again, would exhibit the same appearance, as before, and explode in a flash equally intense.

Mr. Cross, a literary gentleman of England, passed several conductors for some distance over the trees in his park, and connected them all with a single one, which passed down through his parlor. In this main conductor, which passed through his parlor, he had a joint, so constructed, that he could break the connection, and leave a short interval between the two sections. Whenever he made the separation, whether in fair weather or in foul, there was a constant succession of brilliant electric sparks, passing from one conductor to the other. Without this disconnection, the electricity would have passed over the conductor in just as great a volume, but would have been invisible or latent, and, of consequence, been the same precisely as if radiant.

The fact that luminous and invisible electricity are the same, though condensed more, in one instance than in the other, can be incontrovertibly proven, by an experiment with what is called the spiral tube or diamond neck lace. Over the glass, at very small intervals, are glued little pieces of tin foil. There is probably a hundred of those pieces, in a distance of two feet, and, as many spaces between them. Now, communicate a spark of electricity, either from the electric machine or a charged Leyden jar, and, 'in its passage through the tube, it will become alternately luminous and la tent one hundred times in the distance of two feet, which certainly, would not be the case, if electricity is destroyed or changed at all by explosion. It is latent, when passing the tin foil, and luminous, when passing the intervals, simply because it is more diffused upon the tin foil than in the spaces. Such an alternate arrangement of tin foil and spaces might be extended, until they should number many millions, and an electric spark would become alternately luminous and latent as many millions of times, in its passage over them. All the difference, then, between radiant and invisible electricity is in volume or condensation, and light and heat, as we have seen, exhibit precisely the same analogies.

We will here briefly enumerate a mass of additional facts, which show the identity of caloric, light and electricity.

Good conductors of heat are also good conductors of electricity and poor conductors of the one are poor conductors of the other.

Heat affects bodies inversely according to the squares of the distance. This is the organic law of light, electricity and magnetism. It speaks volumes in favor of the proposition that the sun is the fountain of all electricity, since the bas isof this principle, which runs through all the imponderables, seems to be laid in the law of the divergence or radiation of light.

Heat radiates in all directions like light, and its angle of incidence and of reflection are the same.

Vessels containing a hot liquid will radiate heat much faster, if they have a rough surface, than those which have a smooth and polished one. The reason of this is, because the rough surface has a great number of minute *points*, from which the heat will escape, the same as electricity. The polished vessel has no *points* for radiation, and, therefore, retains the heat.

In accordance with the same law precisely, a polished vessel, containing cold water, when placed before a fire, will not be heated

so quickly, as one having a rough surface, because it prese
points to attract heat, but reflects it rather.

A multitude of other facts could be collocated, to prove
sively that caloric and electricity are identical, but we mus
the remainder of our remarks to the next lecture, where w
to demonstrate, among other things, that caloric is, in fact, th
ning of the clouds.

LECTURE XII.

SUBJECTS—HEAT—MAGNETIC ATTRACTION—THE AURORÆ.

So important is the demonstration of the proposition, that caloric is identical with the other imponderables, that we need offer no apology for its prolonged discussion.

That was an important era in the history of science, when the lightning of the clouds was identified with electricity. Quite as important will be that era, when *caloric* and that lightning shall be demonstrated to be one and the same thing. If that ever take place, the propositions we have assumed will be proven to be correct, beyond the possibility of cavil, or the shadow of a doubt. This subject, then, is richly worthy of a thorough investigation· What are the phenomena, attendant upon a thunderstorm, and what are the causes, which conspire to produce it. Storms, attended with thunder and lightning, seldom occur, except in very warm weather; and the warmer the weather, the more frequent they are, and the more vivid, rapid and intense are the lurid flashes of the red bolt of heaven. They prevail in the northern zones in the summer, in the southern in the winter, and in the torrid regions throughout the year. This is the "modus operandi" of their doings.

During the hot weather of the summer months, a vast amount of caloric is poured down from the sun, and diffuses itself throughout the waters of the fountains, rivers, lakes and oceans of the globe, and produces evaporation; for, it is a fact, which is generally acknowledged, and which no one will dispute, that caloric is the vaporizing agent the world over. This vapour, when generated, rises, we know and forms the clouds. The caloric or heat, which originated it, is absolutely required to keep it in a state of vapour ; for, the moment it is abstracted by any process or cause, whatever, that moment vapor ceases to be vapor. and is condensed into water again. This is proved by the condensation of vapor or steam, in a low pressure engine, instance, where, by the abstraction of its caloric by cold, it returns to water.

Now, what takes place during a thunder storm, after a hot sultry day, in which vast quantities of vapor were generated, and with which vast quantities of caloric rose to keep it in a state of vapor—what takes place we ask during a thunder storm at such a time?—Why simply this. Clouds that are charged with caloric, some plus and others minus, or some positive and others negative, are drawn together, by the strong attraction of opposite polarities, two clouds, having an affinity for each other, rush together—the caloric which kept the vapour in a state of vapor, is thus given out from one to the other—*explosion takes place—the cause which produced the vapor, and kept it so, having vanished, it is condensed, of course,* into water, and being then heavier than the surrounding medium—heavier than the circumambient atmosphere, which before sustained it, it is immediately precipitated to the earth by gravitation, in the form of showers.

If a thunder storm be watched, during the process of nimbification, it will be seen that little dark clouds seem to congregate from every point of the compass, sometimes, and will conglomerate and thicken into deeper and deeper density and darkness, those, which have the least caloric run the lowest, while those which have the greatest quantity, run the highest; as they come parallel to each other, the lower strata will lift, while the upper will settle down, being attracted by each other, until they come within striking distance, when the plus of the upper strata is given out to the minus of the lower, in an explosion, and, during this concussion, a large share ic, which was treasured up in the vaporous vessicles of , is abstracted in thunderbolts, and thus copious dischar- nsed vapor or water follow each flash.

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e rationale of aerial condensations. When a cloud is l, having parted with a portion of its caloric, *it is minus* o all uncondensed or transparent vapor, which is plus. ecomes a centre of attraction, drawing to it successive apour, and abstracting their caloric, by which a perpetual condensation or nimbification is kept up, until an equilibrium is restored.

It would seem obvious to the most superficial observer, that caloric is the cause of evaporation, inasmuch as the greatest amount of evaporation takes place in regions which receive most of the sun's heat. We may form some idea of the vast amount of caloric contained in atmospheric vapor, when we reflect, that a pound of vapor will raise the temperature of a pound of water nearly 1000 degrees—that its bulk is increased about 1800 times in passing from a state of water to that of vapor, and that all the rivers of the earth are supplied by its precipitation.

What then becomes of all the caloric which must be given out during the condensation of this vapor? We know that thunder and lightning are most abundant in tropical regions, and during hot, sultry weather in the middle lattitudes. Hence we infer, *that the caloric of vapor, when greatly accumulated, is given out rapidly, in the form of electricity, on approaching a colder mass of vapor, which is negatively charged with caloric.*"

But it may, in this connection, be asked, what causes rain, when lightning is not visible. The caloric is given out gradually, and, in such a volume that it is latent. This is either done by the vicinity of cold and warm masses of vapor, or the attraction of mountainous ridges, or of the minus earth.

If this be true, we can see, at once, the reason why, upon the great desert of Zahara, where there are no mountains, and where the earth is almost always plus, it rarely, if ever, rains. The earth, being plus, and imparting caloric to the masses of vapor, as they float over it, rarefies them, and makes them float *higher*, rather than aid in their condensation. It would be utterly impossible, therefore, for it to rain, oftener, upon that desert.

The same cause dissipates all appearances of rain in certain sections during the prevalence of a drought, so that showers will pass round day, each side of them, and seem to shun them. The earth, ose sections, become plus and rarefies the clouds, as they loats them higher, and *prevents* condensation. As a generence, such spots are encroached upon *gradually* by showers, are, at length, made minus, and then they are visited by shing rain.

a large tower be erected, some one or two thousand feet the very centre of the great desert of Zahara, and could its pt filled with *ice*, it would be the cause of the *perpetual* nimof clouds, by its abstraction, of their *caloric*. The consequence that it would be visited with frequent and vivifying showers. in is the great fountain of light. Were it, however, extinas in Byrons poetic dream on darkness, there would be nei- nor electricity, and on the other hand, were there no heat ricity, there could be no light; for light is necessarily pro- y the heat, which is indispensably requisite, to render subombustible, and, without which, they would not ignite, nor combustible, nor luminous at all. They are inseparable h other, and from electricity, and if you destroy the existhe one, by the same process, you destroy the existence

ct is, the sun, which sends forth its streams of light and he great fountain of electricity—the great galvanic battery lar system. Could it be stripped, at once, of these splenich sweep incessantly over the vast domain of its dependent and be left a dark, cold, opaque body, what think you, would nsequence? Why, in less than twenty four hours, yea, in twelve hours, this globe would become a solid mass of ice, face to centre, as well as every other body of the solar syshe very atmosphere would, be congealed into an iceberg.— rt of nature would cease to beat, The pulse of nature and still:—The powers of nature would all be palsied, chill-ed, and frozen to death. In such a supposed contingency, the orbs, if they moved at all, would wander, cheerless, black and without order, through the vast expanse of desolation, dashing madly against each other, in their blind and ungoverned career.

Or else, as is most probable, in such a contingency, all motion would be stagnated, and every energy, every muscle, every nerve of the universe would be withered, stiffened, clothed with the rigidity of death. All sound would die away upon the palpable blackness of chaos. No elastic medium would convey the tones of harmony by its vibrations. All nature would be dumb.

While thinking upon this subject, I have permitted imagination, sometimes, to have unfettered sway, and to sketch the gloomy picture of the reality of such a supposition. In doing so, no description of the scene which I could paint, seemed so graphic, as the language of Byrons poetic dream on darkness, when

———The world was void:
"The populous and powerful was a lump
"Seasonless, herbless, treeless, manless, lifeless,
"A lump of death—a chaos of hard clay.
"The rivers, lakes and oceans all stood still,
"And nothing stirred within their silent depths.
"Ships sailorless, lay rotting on the sea,
"And their masts fell down piece meal—
"As they dropped, they slept upon the abyss without a surge.
"The waves were dead. The tides were in their graves—
"The moon, their mistress, had expired before,
"The winds were withered in the stagnant air.
"And the clouds perished. Darkness had no need
"Of aid from them—SHE WAS THE UNIVERSE.

This description, or a description like this, though almost horrid enough, to make the blood run chill, would be no fiction. Should the light and caloric of the sun be abstracted from the universe, there would be no electricity. It would, with the rapidity of a flash, conplete its circuit, and perish with its cause. It could be no longer excited by friction. No galvanic arrangement of metalic plates, could produce it. And then, motion would cease;—All life would instantly become extinct, and darkness and death would reign triumphant and universal.

In view of the facts and arguments, which have already been submitted to the reader, we shall, now, consider it a conceded point, that we have *proven* the *identity between solar light, caloric and electricity*. To test, still farther the correctness of the principles advocated, we will proceed to account, if possible, for certain mysterious and hitherto incrutable phenomena, which can be satisfactorily accounted for, if our positions be, at all, tenable.

There have, for ages, been certain vague and indefinite ideas, floating in the public mind, respecting the cause of magnetic attraction. While some have thought, that there was a certain incomprehensible control over the needle of the compass exerted by the north pole star, others have approached somewhat nearer to scientific accuracy, by ascribing this controling influence to terrestrial magnetism. But *how* terrestrial magnetism is produced, and by what laws it is governed, the later class have been about as much in the dark, as the former. But, if the positions we have assumed be true—if solar light and heat be electricity, and, if the sun be its fountain, we have a key, which will unlock all this mystery, which has hitherto been so inscrutable. To this important and useful purpose we will then apply it.

How, upon the theory, that the sun is the fountain of electric influences, is terrestrial magnetism accounted for? The sun being the great galvanic reservoir, pours its streams of light and heat, *vertically*, upon the space embracing 47 degrees of the earths middle regions, or 23 ½ degrees each side of the equator, constituting the torrid zone. Let the temperature of the other zones vary as it may, the heat of the torrid is always uniform; and alw [illegible].

compared with either the temperate or the frigid zones. Thus the torrid regions, by being more directly under the influence of the sun's rays, become more deeply electrified, than either the temperate or the frigid. What is the consequence? The equatorial regions are positive or plus, while the polar regions are comparatively negative or minus. There are two reasons for this. The 47 degrees, or the [illegible] square miles of the earth's surface, embraced between 23½ degrees of north, and 23½ degrees of south latitude, constitute the thickest part of the globe, and, even if the remaining part, including the north and south temperate, and north and south frigid zones, were as directly exposed to the same rays, as is the torrid, (which supposition is, however an impossibility,) the equator would, in that case, still be plus and the poles minus, because the torrid regions are the thickest, and receive, therefore, the greatest amount of the electric fluid.

But the principal reason why the one is plus and the other minus, is because the one receives the rays of the sun more vertically than the other. Now for the application of an infallible rule. The equatorial regions being plus, or positive, and the poles being minus or negative, there is a mutual attraction of the plus or superabundant fluid of the one, and the minus of the other, upon that immutable and universal chemical principle, that opposite polarities, or a positive and negative always attract, or that caloric always seeks to keep up an equilibrium or to restore it when disturbed.

Besides, from this immutable and universal law of caloric, to keep up or restore an equilibrium, its particles, if they have opposite polarities and if the plus end, in radiations, or emanations, always moves first, must present, at the magnetic equator, their minus polarities to each other, and of course, be continually repelled outward each way towards the poles.

So, then, there are actually two forces operating upon the superabundant electricity or caloric of the equator. And what is the consequence of the combined action of those two forces. Why, there will be two strong currents of electricity, rushing, continually, with lightning [speed, from the equator, each way, and these currents will, if this theory be true, run towards the point of greatest cold, north and south, instead of the geographic pole.

Some, perhaps, might contend, that if the streams of caloric constitute the directive power, which is exerted, by some agent over the needle of the compass, they must move spirally, in order to exert that influence, which is actually exerted. Such may confidently infer this, from the fact that certain experiments have been made, which would seem to prove it. A sheet iron globe has been constructed, and so wound spirally, from the north to the south pole, with insulated copper wire, that it would make the needle arrange itself north and south, whenever the galvanic current was sent through the wire from one pole to the other, by connecting the wires at the two poles with the poles of the galvanic battery.

But the inference, that such must be the spiral course of the electric current around the earth, by no means follows from this experiment; for, it must be recolleeted, that there are two different currents, or two currents, running in opposite directions from the equator to the poles, with their polarities arranged, of course, in opposite directions, the same, precisely, as if, from the equator towards the poles of such a hollow sphere, two currents should be sent in opposite directions from two galvanic batteries. By such an experiment, it could be demonstrated, conclusively, that the needle would arrange itself north and south, without having the galvanic fluid circulate around spirally.

But it would not discredit the correctness of our theory at all, if it were necessary that there should be spiral currents, for there is, doubtless a *minor* current, running spirally around the earth, from west to east, owing to the fact, that, by the diurnal revolution, that side of the earth, which is in darkness, is relatively minus, when compared with that part, which is under the immediate influence of the sunlight.

Now then, for the explanation of magnetic attraction. It has been ascertained by experiment, that currents of electricity will influence the needle. The reason then, why the north pole guides the needle when north of the equator, and the south pole when south of the equator is perfectly obvious. These currents of electricity, rushing from the equator to the poles, constitute what is called terrestrial magnetism. They give direction to the needle of the compass.—As the point of greatest cold varies, so they vary, and as they vary so the needle varies.

Were the Geographic pole of the earth the point of attraction, as has been supposed by some, the needle would *never* vary *at all*, but, as it is, it varies both diurnally and annually, because there are causes always operating at the north pole to change the point of greatest cold, particularly in the summer season, when the floating icebergs or ice islands of the Arctic are continually changing their position.

There are other mysterious phenomena which can be rationally and philosophically accounted for, *only*, upon the supposition, that there are such currents of electricity, as we have been describing.—They are the Aurora Borealis and Aurora Australis or the northern and southern lights, for there are southern lights as well as northern. If caloric be electricity as we have supposed, and there are currents passing from the torrid, to the point of greatest cold, in the frigid zone, the question arises " what becomes of this electric fluid, when it arrives at that point of greatest cold ? " Why, it streams up into the rarer regions of the atmosphere, and in its return to the equator, it spreads out into the lambent, waving light, exhibited by the aurora, the appearance being the same precisely, as electricity exhibits, when passing through an exhausted tube, the same cause —the rarity of the atmosphere, operating in both cases, to produce the form of an explosion, and, during this concussion, a large share of the caloric, which was treasured up in the vaporous vessicles of both clouds, is abstracted in thunderbolts, and thus copious discharges of condensed vapor or water follow each flash.

This accounts for the reason, why the bolt, most generally, passes downward from the cloud to the earth. The upper strata being plus, gives out its caloric to the lower, which is always relatively minus, and, therefore, the scathing fires of heaven oftener leap downward than in any other direction.

Lightning, then, or the electricity of the clouds, is nothing more nor less than caloric, abstracted from vapor by strong chemical affinities, and by explosion. It is radiant caloric, and caloric is Electricity. We believe that no philosopher, or chemist can account for all the phenomena of the thunderstorm, and of the lightning, in any other way.

To show that we stand not alone in the advocacy of such sentiments, we will quote from that rare and excellent work by Dr. Metcalf, entitled a new theory of terrestrial magnetism.

"It was observed, long ago by Dr. Franklin, that masses of vapor, in different states of electricity, attracted each other far beyond what he called the striking distance.

It has probably been remarked by every person of observation, that light masses of vapor from the ocean, on approaching a mass of colder vapor from the northern points of the compass, approximate each other with accelerated velocity, when the colder current of vapor attracts caloric from the warmer; and it is condensed into a hazy mist or cloud.

This is the rationale of aerial condensations. When a cloud is once formed, having parted with a portion of its caloric, *it is minus* in relation to all uncondensed or transparent vapor, which is plus. So that it becomes a centre of attraction, drawing to it successive masses of vapour, and abstracting their caloric, by which a perpetuthat caloric is, in fact, electricity, short of actual mathematical demonstration? One, who could not be convinced by such an array of facts, each supporting the other, could hardly be convinced, we should be inclined to suppose, by the evidence of his senses. He would be like that antient sect of sceptical philosophers, who doubted every thing—even their own identity.

In our next lecture, we shall connect together several other important links, in our chain of testimony in favor of the identity of all the imponderables.

LECTURE XIII.

SUBJECTS—GRAVITATION—COHESION—MOTION OF PLANETS.

In continuation of our explanations of various mysterious phenomena of nature, which have, heretofore, been left unexplained, or enveloped in a metaphysical fog, we would remark, that there are yet other important and essential links, in the chain of evidence, which we have been linking together, all of which will have a tendency to make the logical accuracy of our deductions more clear, and our conclusions more and more undeniable and convincing.

Gravitation, another imponderable principle of nature, is one of those links—a link too which, so far from diminishing or imparing, in the slightest degree, the strength of the previous chain of deduction, adds to it increasing power of tenacity, and resistance to efforts of prejudice or scepticism to break it—a link, which is intimately connected, as we shall attempt to show, with the mysterious power of electro-magnetism.

No topic, in the whole range of the sciences, has, heretofore, seemed to students more unaccountable—more involved in a dark and misty shroud of uncertainty, than gravitation. Upon what known philosophical, astronomical, or chemical law, bodies, within a certain distance, are attracted *towards* the earth, has, for a long time been regarded by the learned and treated, as an inexplicable enigma.

It is no solution of the riddle—no satisfactory explanation, to affirm, that it is *attraction*. If the attempt be made, by any one, so to define it, the question instantly suggests itself to the unsatisfied mind of the dilligent enquirer after scientific truth—what *causes* this attraction—why do all bodies, when unsupported in mid air, fall *to* the earth, instead of flying off in a tangent—*away* from it, into space?" We answer, that there must be some *definite* reason existing in the nature of things for this phenomenon. What, then, is that reason?

It will not avail any thing, as we have seen, to say, that it is attraction, or, that it is the attraction of Gravitation. This method of solving the enigma would only be reasoning in a circle, as logicians would call it—would be only giving a simpletons solution, by saying that a thing is so, *because* it is so. It conveys no definite idea to the mind—is referable to no general scientific law. So far as purposes of lucid and perspicuous illustration are concerned, it might just as well be said, that attraction of *attraction* causes that known disposition of bodies to seek the earth, as to be said, that the, attraction of *gravitation* causes it, for, the words, indicating or defining the *cause*, are, in both cases, equally vague, having no definite idea attached to either of them. If we are told that all bodies of any bulk and density, have an inherent tendency to approach other bodies of matter larger and heavier than themselves, upon the principle of attraction, and that this is the attraction of gravitation, is it any explanation at all? Certainly not. Instead of throwing any light upon the subject, it is only the substitution of one vague term, for another term equally vague. The question still rushes upon the unsatisfied mind, with undiminished force—"What *causes* this gravitating tendency? Why do bodies tend downward towards the earth instead of upwards from it?"

Shall it be said that it is an insolvable mystery, which is beyond the ken of human investigation, and so let it pass? Will men permit themselves to be thus baffled in their researches into the nature and causes of things, by difficulties, which, perhaps, a stern and unbending perseverance might overcome? This would be neither wise nor manly. There is not, we are persuaded, the cause of a single solitary effect of any kind in the universe, except the great uncreated Cause of *all* effects—or, in other words, a single seccondary cause of any effect whatever, which may not, in time, by patient and persevering investigation—by comparing laws and agencies and influences, be satisfactorily ascertained.

What, for instance, is a fundamental law of electrical attraction?—Why, an excited body, attracts an unexcited body, that approaches it, in exact proportion to the squares of the distance. Iron, when temporarily magnetised by the galvanic or electric fluid, or steel, when permanently magnetised, attracts contiguous metals precisely in the *same proportions*, and, although magnetism and electricity, were once thought to have no sort of alliance with each other, yet, they are now proven, beyond controversy, to be but one. And what may we infer from this coincidence between the two, and the identity of their laws and agencies? Why, that any other imponderable, which shall exhibit the operationof the *same governing laws*, without a *shade* of difference, may, also, yea, and will be found to be produced by the very same *cause*, upon the immutable principle of nature, that like causes produce like effects.

Here then we have a key to unlock the mystery of gravitation—a rule to solve every enigma, and every difficulty satisfactorily. The attraction which the earth exerts over lose bodies above its surface, is governed by the very same laws precisely, as magnetism and electrical attraction—it draws them, with a force, which varies in inverse proportions according to the squares of the distance.

Gravitation, then, is nothing more, nor less than terrestrial magnetism, produced, as all magnetism is produced, by electricity, and that electricity, streaming down from the source of all electricity, the sun. Before this theory, every difficulty which surrounds the subject of gravitation, vanishes at once. The phenomena of bodies gravitating towards the earth can be thus accounted for by the operation of known, and acknowledged, and tested scientific laws. The earth is, in fact, a magnet—exhibiting all the properties of a magnet—attracting the needle to the pole like a magnet—drawing bodies to itself with a force precisely conformable to the attractive force or influence of a magnet, is made a magnet by electricity—and that electricity is the light and caloric that stream from the sun. The attraction of gravitation, then, is the attraction of terrestrial magnetism.

It has been the current opinion, among the mass of the community, and even among scholars, that every thing is attracted towards the centre of the earth, as though that possessed some mysterious, unaccountable power of attraction over substances, somewhat akin to the unphilosiphical opinion, that the North pole star guides the needle of the compass, and that it increased all the way to that centre. But such is, by no means the case. - The attraction of Gravitation, instead of being the greatest at the *centre*, is the greatest at the *surface* of the earth.

Were it possible, for instance, to perforate *through* the earth, exactly at the magnetic centre, instead of the geographic, a substance, which might weigh hundreds of tons at the surface, would weigh just nothing at all at that centre. It would be suspended there, were the space large enough, without any apparent support, like a light needle, when suspended within a helix, or coil of insulated copper wire, while passing a current of galvanism around it. And why would this be the case? Because the electrical or magnetic attraction would be equal on all sides of the centre of the earth, and, therefore, a substance, which would weigh several tons at the surface, would there be perfectly ballanced, without support, and would, in that position, weigh just nothing at all, since all weight depends upon attraction, and that weight is exactly proportional to the attraction. As the power of the attraction is equal on all sides of the centre of the earth, and, as attraction *one* way, without a corresponding attraction the *other*, causes all weight, therefore, a substance at this centre, must weigh nothing, because the attraction being in all directions equal, must be neutralized.

The attraction of gravitation, or, in other words, the attraction of terrestrial *magnetism*, which is the the same thing precisely, is the greatest at the *surface* of the earth. It may be asked, then,—"Why do all falling bodies, fall toward the centre?" Simply because the radiations of magnetism obey the same law, precisely, as the radiations of light. The lines of these radii if continued on within the surface, or through the earth, from one side to the other, would intersect the centre, and the attractions of the surface are, therefore, directly *toward* the centre.

From the fact, that the radiations of magnetism, obey the law of the radiations of solar light, and all other light,—that is, from the fact, that the divergence of the radiations of magnetism is, in the exact proportion of the squares of the distance, the same as the divergence of light, Gravitation, therefore, attracts all bodies around it, in proportion to the squares of the distance of those bodies. So that the organic laws of magnetism, light and Gravitation are the same, and, like *laws* produce like effects as well as like *causes*.

Before dismissing the interesting subject of Gravitation, we would express our belief, that it is a proposition, capable of demonstration, that an increase of the material of the earth, would increase its attraction, in precisely the ratio of the increase of the attraction of the magnet, by the increase of *its* material. Were the material of the earth *doubled*, for instance, its attraction would be *quadrupled*, precisely in accordance with the law of the divergence of light, or the radiations of electricity. Consequently the weight of all bodies upon its surface, of the same bulk and density, would, in such a supposed contingency, be quadrupled in accordance with an immutable law.

Now, from all that has been said, does it not appear perfectly evident, that gravitation has a cause, as definite and as easily explained, as magnetism, which cause is precisely the same. The great magnet of Professor Henry, for instance, to which we have already alluded, would, when fully charged with the galvanic current, *neutralize* all the power of the *earth's* gravitation. and make a body gravitate *upwards* from the earth, with a power equal to *two or three tons*.—And why? Simply because a vast volume of electricity was accumulated there in a small compass, by means of the insulated copper wires, around which the galvanic fluid circulated. Electricity or light, then, we can legitimately conclude, is the *cause* of gravitation.

The attraction of cohesion has the same cause, as the attraction of gravitation. They are both, doubtless, produced by that electric cause, the light and caloric of the sun. The one is the attraction between *large masses*, and the other between the component *particles* af those masses, the one attracts at great distances, and the other at insensible distances—their attractions are, therefore, the same in essence, though not in volume or degree. What holds the armature of Henry's large magnet, when charged, but the simple power of cohesive attraction between the particles of the iron, which composes the material of the magnet and armature, which cohesive power is caused by electricity? We believe it is nothing else. The same power, precisely, holds the particles of all bodies together, and that power of cohesive attraction varies often as the amount of *latent caloric* varies. Abstract the latent caloric of iron, for instance, by intense cold, or by any other cause and you, in a proportionable degree, destroy its cohesive attraction, and make it brittle. This is proven by the ease, with which iron is fractured, in the intense cold of the winter.

By hammering iron when cold, or by rolling it in a rolling mill, it will also become brittle. And why? Because the caloric which constitutes cohesive attraction, is pressed out upon the surface, by closing the pores. This is proven by the fact that caloric accumulates upon the surface, in proportion as the pores of the iron are

l by the rolling mill or the hammer, which drive out the la-
ic.

ious phenomena of capillary attraction can be referred to
:ause, as cohesion—to the caloric, that electrifies all sub-
der its influence. The tallow, that composes the candle,
e, is drawn up into the wick, during combustion, by capill-
ion, and that attraction is caused by the caloric set free du-
ion.

well aware, that many objections to the validity of our pe-
: be started by fruitful imaginations, which may appear
ınd seem to conflict with the conclusions, which we have
t which must be deceptive, since the laws of nature do not
, if some of the reasons, and the modes of her operations
l the ken of the acutest and most penetrating scrutiny, it
ɔ no conclusive proof that we are incorrect. The ques-
ply this. Have our deductions appeared rational, and ın
› with known and tested laws, and have they been amply
by an accumulation of appropriate facts? If so, we are un-
igation to explain mysteries in the *essential attributes* of an
le we are attempting to trace merely the *effects* of that
ınost of those objections, which are or may be started,
nd, upon close scrutiny, to relate to *essence* rather than to
s operandi, of that essence.

estions as these, for instance, may be asked by the cavill-
ɔr. If caloric be the *cause* of cohesive attraction, why will
lation entirely *destroy* cohesive attraction, as in the instance
ed metals? Or, if caloric be electricity, and, if electricity
isın, why does not its accumulation around the large gal-
net, make that large magnet hot? Or, why will this
ler one set of circumstances, produce an effect, and under
estroy that same effect, it produces, if "like *causes* produce
?" These, and a thousand other questions, might be pro-

posed by the objector, which are more easily asked than answered.

But, to show that they relate to *essence*, we will ask some questions equally puzzling, about electricity, where there can be no mistake about the identity of the agent. Why will the very same current of galvinsm produce *both* an *acid* and an *alkaline* taste? Why will electricity, under one set of circumstances, make a magnet, and why, under other circumstances, will it *destroy* that same magnet. It will be readily perceived, that it is much easier to "*ask* questions than to *answer* them," and that such questions refer rather to an explanation of *essence* than of *effect*. That *essence* of electricity, we never attempted, nor have we ever proposed, to explain. It is a wonderful agent, and as mysterious as it is wonderful. Its effects are varied by countless myriads of modifications, and these effects, we investigate, rather than the inscrutable reasons, why those modifications should be so multitudinous, and why they should, in some cases appear to clash.

To show that we stand not alone in the advocacy of the opinion, that cohesive and capillary attraction are produced by caloric or electricity, we will quote from Metcalf's "New Theory of Terrestrial Magnetism." Speaking of caloric he says:—"It seems to be a general law of this subtle element, that it repels its own particles, and is attracted, though unequally, by all other matter, with an increased ratio, as the squares of the distance diminish. *

"From which it follows, that when caloric is withdrawn from a body, that body has a stronger affinity for caloric, than one which is filled with it; and two bodies charged with caloric, one plus and the other minus. will attract each other with a force proportioned to the different quantities of caloric which they contain, and to the rapidity of its conduction from one to the other.

"An experiment, which I inadvertently made when a child, strikingly illustrates this principle. On the morning of "cold Friday," as it was called, through the Western country, I applied my tongue to a plate of cold iron, while the mercury was about 15 degrees below zero, when it adhered with such force, that the skin was removed on separating it. Captain Scoresby relates, that frequently such was the intensity of cold in the Arctic seas, that the hands of the sailors adhered fast to whatever metals they touched.

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* We do not believe in the above proposition, so far as reciprocal attraction is concerned. This would, as we have elsewhere shown, destroy the "vis inertiæ" of ponderable m

"In all such cases the temperature of the living body is from 115 to 140 degrees higher than that of the metals:—in other words, the living body is charged plus, while they are minus; and the attraction continues until the equilibrium is restored, when it ceases.

"The same attraction takes place, when the hand is applied to metals heated greatly above the temperature of the living body; and for the same reason, one of the two bodies being charged plus and the other minus.

"When the temperature of metals is greatly reduced, they become brittle, so that a slight blow will fracture them; the same effect is produced on iron by hammering, which presses out, and expels from it, that portion of caloric, which is necessary to its cohesion and malleability. Hence it follows, that a certain amount of caloric between the particles of matter is requisite to maintain their cohesion; but when the amount of caloric is increased beyond a certain extent, it separates the particles, and thus diminishes, or overcomes, the power of cohesion.

"A great variety of facts may be adduced, to show, that *capillary attraction*, is owing to the operation of the same law. For example; if a piece of sugar be put into a glass of water, a portion of the caloric of fluidity leaves the water, enters among the particles of sugar, and diffuses itself equally throughout the whole. During this absorption of caloric by the sugar, the temperature of the resulting mixture is somewhat reduced, proving that, in relation to the water, the sugar is minus or negative, and the water is plus or positive.

"If the piece of sugar be cut into a cylindrical form, of one or two inches in diameter and five or six inches long, and one end of it only be inserted into a glass of water, the caloric of the positive fluid being *strongly* attracted by the negative sugar, pervades it rapidly throughout, until the equilibrium is restored, when the entire mass is dissolved.

"M. Lehot found by experiment, that under the same pressure, water rises higher in vertical capillary tubes, as its temperature is elevated. (Bibl. Univers. Mars. 1820, p. 225.)

"The phenomena of a burning candle illustrate the agency of caloric in producing capillary attraction in a very striking manner.—The wick is ignited, the tallow rendered fluid, and attracted by caloric so as to furnish a continual supply of combustible matter to the wick, which is decomposed and expanded into flame or light.—The force and rapidity of capillary attraction, all other things being equal, are in proportion to the amount of heat given out in the wick.

"Capillary and cohesive attractions are only modified effects of the same cause. It is the attraction of caloric for the particles of water, that holds them together; that gives its drops their globular form; as it is the attraction of caloric for porous solids, and capillary tubes, that raises the water above its ordinary level."

If light and caloric be electricity, and the sun be the sole fountain, from which it issues, as we have attempted, in previous lectures, to demonstrate, then its influence over the planets, that revolve around it, must also be an electric influence. If their motions are produced by the influence of the sun, then, those *motions* must be governed by the laws which govern the electric agent.

We approach the discussion of this subject, with the feeling, that it is the most important, as well as the most interesting of any contained in the whole series of lectures. If we shall demonstrate, that the revolutions of all the planets, both diurnal and annual, can be philosophically accounted for, in accordance with those organic laws of electricity, which have been, and may be ascertained definitely, in the laboratory, in their action upon pith balls or electrometers, then will our opinions upon this subject be triumphantly sustained beyond the influence of cavil, and their correctnes incontrovertibly proven. But, if we shall not be able to demonstrate such an identity, then will it appear conclusive, that we have been indulging in philosophical dreams, or baseless chimeras of the brain.

What then are the forces, which electricity exerts over pith balls? They are two, which, as we have, heretofore, abundantly shown, have their basis in the inherent organic laws of this agent, and depend always, for their developement, upon a plus and minus.

And what are the two forces, which have ever been supposed to govern the motions of the planets? Why they are, what philosophers have denominataed, centrifugal and centripetal forces. The meaning of the one is, a tendency to fly from a centre, and that of the other, a disposition to seek the centre. Now these terms are, as any one must see, exactly equivalant to attraction and repulsion.—Centrifugal is repulsion and centripetal is attraction. So then, we find, that we have to bring to our aid no new forces, if we adopt the hypothesis, that the influence of the sunlight upon the solar system, is electric, since its two organic forces, correspond exactly to the centrifugal and centripetal, of all standard works.

How then is the diurnal motion of the earth, for instance, produced upon this hypothesis, taking the movements of this globe for example, since they are more familiar than those of any other planet. Why, simply in this manner. The sun illuminates one half of the surface of the globe, while the other half is in darkness. That hemisphere, which is in darkness, is relatively minus, when compared with that which is illuminated, and so, vice versa, that hemisphere, which is under the direct influence of the radiance of the sun, is relatively plus, while the other is minus. The plus of the one side will increase from morning until sundown, and the minus of the other from sundown until morning. This is in accordance with that tested fact, that, if any substance be exposed to an electrifying cause, it becomes plus, and the longer it is exposed to that cause, the more highly plus it becomes, and so, on the contrary, if any substance be removed from the electrifying influence, it becomes minus, and the longer it is removed, the more deeply minus it becomes. Now, what is the legitimate result of such a condition of the earth? That part of the earth, which has been longest in the suns rays, has come, as we have said, to a highly plus or positive state—that is, it has come to that state, in which, throughout the torrid regions and part of the temperate, there must be an outward outward emanation, which constitutes a plus or positive, since any substance, exposed, for any length of time to the electrifying cause, must become positive.

By an immutable law of electricity, two positives repel. Therefore, that part of the earth, which has been longest in the suns rays, having come to a positive condition, is repelled by the positive sun. But that part which has been the longest removed from the direct influence of the electrifying cause, and has, therefore, come to a deeply negative condition, would, of course, be attracted by the positive sun, since a positive and negative always attract. If this were the true principle of the revolution of the earth upon its axis, the plus part of the earth must be always rolling *away* from the sun, while the minus part must be always moving *towards* it, from the fact, that two positives always repel, and a positive and a negative always attract. And this *is* the case, not with the earth only, but with all the planets, which compose the solar system. That part of all of them, which has been longest *in* the suns rays, is always rolling away from him, while that part, which has been the longest *out of* his rays, is always rolling towards him. In producing the rotary motion of the earth, then, upon its axis, it is evident that the sun exerts two forces upon it, the one of attraction and the other of repulsion, which, would cause its diurnal revolution, since, if you strike a ball on each side with equal force, and in opposite directions, you give it the rolling motion.

The earth, then, revolves on its axis daily, by the influence of the two forces of attraction and repulsion, exerted over it, by the sun, and those are precisely analogous in every respect. to those of electricity.

If this be not the precise influence, which the sun exerts over the earth, in the production of its diurnal motion, what is that influence? It is univeasally acknowledged, that the sun governs all the motions of the earth. But, while such an acknowledgment has been made, there seems to have been no clear or well defined idea, in the minds of those, who have made such an acknowledgment, as to what constitutes that ruling power. They have almost universally taken it for a conceded proposition, that such a ruling power of nature controls the movements of this globe of ours , but how it exerts such a control, they seem scarcely to have taken the trouble to enquire.

But, if the sun governs the motions of the earth, it governs those motions in accordance with uniform, well-defined and immutable laws. Now, if any one affirm, that the sun controls the movements of the earth, he is bound to explain the principles of that government. If he cannot, how does he know that there is any such government *at all*. He has no right to assert, that one thing is governed by another, without he can give some definite reason, or reasons, *why* he draws such a conclusion. Nor has he any right to object to conclusions, which others have drawn from well defined premises, and deductions founded in reason, and sustained by well attested facts.

We, for instance, have assumed the proposition to be true, and have endeavored to prove it, that electricity is the cause of all attraction and repulsion, upon both a large and small scale, and, consequently, of all motion among spheres, as well as atoms, and, that the sun is the fountain, whence it originates. As part of a connected chain of antecedents and consequents, or of causes and effects, we have drawn the legitimate conclusion, from the practical results of this theory, that the sun governs the earth and the other planets of the solar system by an electric influence. That influence has been *tested* in the laboratory upon pith balls, and is, therefore, acknowledged by all, who pretend to any very extensive attainments in science.

Now we have shown that the diurnal motion of the earth can be produced, by the streams of electrifying sun light, *precisely*, in accordance with those known and tested and universally acknowledged electric influences, which are of every day occurrence, and are familiar to every school boy. And if objections be urged against such conclusions, those who urge them, ought, certainly, to be prepared to explain the laws, by which the sun governs the earth, more satisfactorily and plausibly, or else forever hold their peace, and acknowledge their incompetency to do it; for the old stereotyped method of explanation, by referring the whole to the influence of the centrifugal and centripetal forces, without explaining *how* those two forces are produced, will not answer—will satisfy no enquiring mind.

Feeling the force of the deductions, which we have drawn, and seeing the impossibility of denying our conclusions, if our premisses be correct, some may by roused, be the impulse of their alarmed prepossessions, to attack some of those premisses. They may deny that the earth becomes minus during the night, and, therefore, infer that there are no two forces of the kind we have mentioned.—But such cannot have investigated the subject at all. The earth is a rapid radiator of caloric, and, therefore, when the cause of it, is removed, it rapidly dissipates. The consequence is, that, although the emanations of caloric are outward from the earth during the day, especially in the torrid zone, they are inward from the atmosphere to the earth at night, as is proven by the deposits of dew, for these deposits result from the abstractions, by the minus earth, of the caloric of the vapor, which was generated in the day time, and rose from the earth by the force of emanating or plus caloric. The passage of caloric is, therefore, into the earth, at night, from the surrounding atmosphere, and of course, presents its minus polarities, as all inward currents do. This objection falls, therefore, to the ground, for the want of the shadow of a support, and so would every other objection, we believe, because our explanation of the phenomena of the revolution of the earth, is in accordance with the immutable laws of nature.

As we have already remarked, all the other primary planets obey the same laws precisely or are governed by the same influences, in their rotary motions upon their axis, as the earth.

An objection may. however, be urged against this conclusion, from the fact, that there is no uniformity in the diurnal revolution of those, whose notions have been ascertained with certainty, since Venus turns on her axis in twenty three hours and twenty minutes, the Earth in twenty three hours and fifty six minutes, Mars in twenty four hours and thirty nine minutes, Jupiter in nine hours and fifty five minutes, and Saturn in ten hours and sixteen minutes.

Now, why is there so much dissimilarity in the revolution of these planets, if there be a common cause for it, and if the laws, which govern that common cause, are invariable? It must be owing to the different materials, which compose them, to their different powers of radiating caloric, to their different distances from the sun, and also, doubtless to their bulk, Venus is some twenty eight millions of miles nearer to the sun, than this earth, and its day is thirty six minutes longer than ours. Upon the supposition that the power or capability of each planet to radiate caloric decreases in exact proportion as the squares of the distance from the sun increase, about which we shall soon remark more at large, then the revolutions of each primary planet would be regulated in exact proportion to bulk and distance.

The difference between the relative distances from the sun of the Earth and Mars, is forty eight millions of miles, and the difference between the time of their revolutions is forty-three minutes. Now, if we take those three planets, Venus, the Earth and Mars for data, whereupon to make our calculations, we can determine, with mathematical certainty, whether any other causes, than mere bulk and distance, influence the rapidity of their revolutions.

The difference between the bulk of Venus and the earth, in diameter, is two hundred and forty miles, between their distances from the sun, is twenty eight millions of miles, and, between the time of their revolution, or the length of their day, is thirty nine minutes, while the difference between the bulkof the Earth and Mars, the next plannet, is three thousand seven hundred and thirty nine miles, between their distances, is forty eight millions of miles, and their time forty three minutes. Into this account is to be taken, the bulk and influences of the Moon, which the Earth carries along with it.

Without having space to enter into all the minutia of a mathematical calculation in the present connection, it is our impression that, with these data before us, it can be perfectly demonstrated, that the rapidity of diurnal revolution depends alone upon bulk and distance from the sun combined.

This accounts satisfactorily for the reason, why Jupiter and Saturn revolve upon their axis, in less than half the time of the revolution of our earth, although the one be three hundred and ninety-five millions of miles further from the sun than the earth, and the other eight hundred and five millions further;—for Jupiter has a diameter about twelve times as great as our earth, making its bulk more than a thousand times greater than this planet, besides carrying with it four large moons, and Saturn, exclusive of the weight of his enormous rings and *seven* moons, is nearly six hundred times larger than the earth. They may, therefore, in exact accordance with our data, both perform their diurnal revolutions in less than half the time of our earth.

Having come, by our deductions, to the conclusion, that the rapidity of revolution depends upon the bulk of the planets, and their relative distances from the sun, we would here remark, that, if the power or capability of the planets to radiate caloric, decreases, according to the squares of their distance from the great centre of the system, then, there is a *definite* cause why they all occupy just the position they do. Were this the case, they could come no nearer to the sun than they now do, nor could they remove farther away from it, but must remain just in the position they do at present, and have done since creation, so long as their material remains the same, or they have the same power of retaining or radiating caloric.

For, if they should come any nearer, it is evident that they must become plus, and so be driven back, by the repulsion of two positives. And, if they should recede, farther from the centre, they would become minus, and so be drawn to the position, whence they started by the attraction of a positive and negative. It is perfectly evident, then, that the planets are completely ballanced in their orbits. They can neither fly away from them, nor can they be drawn into the sun, for the agent, that rules them, and governs all their motions, holds them just where they are, with bonds, which cannot be broken, until the final "wreck of matter, and the crash of worlds." Owing to this cause alone, the earth approaches the sun, in one part of its orbit, and is driven back in the other, the two forces, keeping it ballanced exactly in strict accordance with that law of caloric, which has a tendency to keep up an equilibrium throughout nature,

Having accounted, rationally, for the revolutions of the planets [illegible] their axes, upon the principles of electrical attraction and repulsion, how shall we account now, for their annual revolutions around the sun. This, we confess, is a subject much more abstruse, and the problem is much more difficult to solve. But yet, we believe that it is capable of being satisfactorily solved, in accordance with the very same electrical principles, which we have already fully explained and tested.

But before we proceed to do this, it is necessary for us to state a few facts, which will aid materially in the solution of this problem.

Not only do all the planets revolve one way upon their axis, but they all move in one direction around the sun. Their motions, also, decrease in regular proportions and gradations, as they recede from the sun. Mercury, for instance moves in her orbit one hundred and eleven thousand and ninety miles per hour—Venus eighty-one thousand—the Earth sixty-eight thousand—Mars fifty-six thousand—Jupiter twenty thousand—Saturn, according to Ferguson, eighten thousand, and Hershel fifteen thousand.

It will be seen that their movements are regulated by distance from the sun, combined with bulk, and, we believe it to be a proposition capable of absolute demonstration, that the decrease of the motion of all the planets in their several orbits, wonld be in exact proportion to the squares of their distances from the sun, if they were all of the same bulk and density exactly, taking the present ratio of their movements, as correct data from which to draw conclusions.

Now, then, for the explanation of the annual revolutions of the planets. The sun seems to turn on his axis once in twenty-five days. That may be nothing but a seeming revolution, owing to the movement of its emanations in vast orbits as we have before remarked, and which would convey that impression to an observer upon this globe ; but it may be real. Be that as it may, all the planets move the same way that the sun seems to revolve, and therefore, the same way that its emanations move in their orbits.

Now by the influence of the rays of the sun, moving with lightning speed in their orbital course, must the planets be all moved in one direction; since all their movements, both diurnal and annual, are governed entirely by the emanations of the sun, as we have seen.—This is, doubtless, effected by the amazing influence, which, as we have upon a small scale, demonstrated, that opposite polarities have upon each other, in inducing the particles of the electric stream to follow each other, and to move with them either atoms or masses of ponderable matter.

"But why," it may be asked. "does not this tendency of electricity to control both atoms and masses of ponderable matter, drag them outward, exactly in the line of the course of its orbital movements?" Because, as we have seen, if they were moved outward from their present position, they must become immediately minus, and be drawn back by the positive sun. Besides, were not this the case, the inward passage of the electric rays, in their return, as we have before explained, to their source, the sun, being with a lightning speed, as rapid as their outward emanation, may have a tendency, somehow, to neutralize the tangential force, and, at the same time, aid in the propulsion of the planets in their orbits, as the propelling force, if they have any, would be in the right direction.

The eccentric movements of the comets are produced by the operation of the same laws, as the movements of the planets. In the most distant part of their orbit, a thousand millions of miles. perhaps, from the sun, or even more, these wandering stars move very slow, and in the arc of a circle almost immeasurable, having lost their charge of caloric, and become minus. The sun, being positive, and they deeply negative, it begins to exert an attracting influence over them. As that attraction increases, continually, in proportion, as the squares of the distance decrease, they move swifter and swifter, until,as they approach the sun, they sometimes fly more than eight hundred thousand miles in an hour. At their perihelion, they are very near the sun, and become highly positive, as they revolve half round in its intense blaze, and are propelled back again into the fields of space with the same lightning speed, that they were atracted towards the great fount of all motion.

In view of what has been said in the preceding series of lectures, how wonderful is the subject of electricity—how various and how magical are its agencies! It streams down in the vivifying rays of the sun—quickens and invigorates the sluggish pulsations of nature—preserves the warmth of vitality—works all the countless myriads of chemical changes—clothes the cheek with the blush of health—spreads a rich carpet of green over the landscape—dresses the forest in its foliage, and has, no doubt, a direct agency, in the production and continuance of all the forms of both animal and vegetable life.

But there is a reverse to this picture. Not always does it, in the exhibition of its wondrous phenomena, put on an aspect of such blandness and genial benevolence, wreathing itself in sunny smiles. No: Its countenance sometimes gathers either mysterious grandeur or terrific fearfulness. Sometimes it streams upward from the poles, in splendid corruscations, and weaves a bright coronal of ambent light at the zenith. Sometimes it exhibits itself in the effulgence and evanescence of the meteors flash, and the meteoric shower. Sometimes it leaps out from the dark foldings of the storm-cloud, darts downward through the gleaming tempest, and, with a fearful energy, which none else but God can wield, blasts every thing it touches. Sometimes it flames athwart the heavens, in the trail of the comet, as it speeds its erratic and lightning course, and makes the nations pale with forebodings. Sometimes it assumes the port, and majesty and terror of the burning whirlwind—rushes forth upon the red wing of the Syroc, and sweeps with desolation, the hot plains of Zahara. Sometimes it musters its almost omnipotent force in the deep caverns of the earths centre, and makes the globe tremble and reel beneath the tramp of the earthquake, and melts rocks, and pours rivers of lava from the craters mouth, and hurls enormous masses of blazing matter above the clouds, and upheaves mountains from the depths of the ocean and piles them in the sky. Such are some of the wonderful agencies of electricity.

LECTURE XIV.

SUBJECTS—ANIMAL MAGNETISM—THE MIND IMMATERIAL.

In the closing lecture of a course which has been devoted exclusively to the subject of elctricity, and its multiform agencies, a passing notice of the mysterious subject of Animal Magnetism, and the Immateriality of mind, could not, very appropriately, be omitted, since they both have a connection, of some sort, with the subjects that have been discussed.

On the one hand, it has been stoutly denied by some, that Animal Magnetism is any thing more or less, than an arrant humbug; and, on the other, it has been, as stoutly affirmed, by a few, that mind is an imponderable material, or electricity exhibiting one of its ten thousand modifications. Now, our object will be, in a very brief manner, to prove that these two classes of individuals are entirely incorrect in their opinions. Animal Magnetism is not humbug, how much soever it may be sneered at, nor is mind material.

It might be expected that, in this connection, we should give a history of the first discovery of Animal Magnetism by Mesmer, and trace its rise and progress to the present. But we shall omit this, for want of room, deeming it, also, unnecessary, since it is so generally known.

To prove that Animal Magnetism is no humbug, we shall first state what we have seen under circumstances, where there could possibly be no collusion, no mistake, nor deception.

We have seen a deaf and dumb boy, about thirteen or fourteen years of age, unknown to the magnetiser, and having had no previous connection with him, placed upon a stage before an audience, there exposed to the steady gaze of the magnetiser for a few minutes, and, while he was looking about upon the audience, with a smile of wonderment at what was passing, we have seen him suddenly fall asleep. After being put in this magnetic condition, we have seen him phrenologically affected by the magnetiser, in a variety of ways, although it was utterly impossible that the boy should have known any thing about phrenology, or, indeed, any other science. When the developement of Benevolence was touched, he exhibited all the known indications of an extremely charitable disposition—when Acquisitiveness was affected by the magnetiser, he exhibited selfish and miserly dispositions, directly the reverse of the former, and when the organ of Motion was touched, he danced about the stage very nimbly.

We have seen the whole system catalepsized, and rendered rigid almost as marble. We have seen the eyes, in particular, so paralized, when wide open, that they would appear glassy and staring, like those of a wax figure, and, in that condition, we have seen a bright lamp held directly before the eye, without causing a wink, or the movement of a muscle, which proved conclusively, that there could be no deception, since no man, with his eyes open, and awake, could possibly so control his muscles.

We have seen a person put into the magnetic sleep, and, in that condition have seen the attempt made, before a large audience, to extract a tooth—have heard it broken off with a snap, which re sounded through the room—have seen the root dug out afterwards, and all this, without a single scowl or the movement of a muscle, or a single sigh, or groan, or symptom of pain. The brow of the sleeper was as calm and smooth during the whole operation, as that of a sleeping infant.

Persons have been put into the magnetic sleep, and their eyes cauterized with lunar caustic, without the starting of a tear, while in that condition, or a wink, or the convulsion of a muscle; and, even. it is well authenticated, that limbs have been amputated, while in the state of mesmeric unconciousness.

Now, what conclusions should we draw from all these facts?—Shall we, with dogged pertinacity in unreasonable scepticism, deny the evidence of our senses? What other medium of ascertaining facts have we, than our senses, and, if we deny their evidence, do we not thereby, discredit the very sources of all our knowledge? Those, who disbelieve the evidence of their own senses, are the humbugged instead of those, who trust in it. Animal Magnetism, then, is a sublime science, instead of being a miserable delusion.

The following extract from a letter of John Neal Esq., of Portland, Maine, to the Rev, Mr. Pierpoint of Boston, Mass. is very appropriate in this connection.

"Seeing is believing, with most people. With me, it is not.—Notwithstanding my respect for my own eyes, and other senses, I am not willing to believe, in all cases, according to their testimony. If I did, I should believe that a straight stick becomes crooked by thrusting it into the water; and that men may swallow half-pence by the handful, or, perhaps thrust themselves inside out—and back again at pleasure.

But while, on the one hand, I do not believe, merely *because* I see—or *think* I see; on the other hand I dare not *disbelieve*, because I don't see. In other words, I do not presume to *disbelieve* what I cannot understand nor explain; for the same reason that I do not *believe*, always, and at all times, according to appearances.

Thus much to prepare you for the following, which I offer as a brief statement of facts. Five years ago, I was neither a believer nor a disbeliever in animal magnetism—or mesmerism. The simple truth is that I knew nothing about it. I had swallowed the report of

Dr. Franklin—I had never met with the protest of Jessieu—and, like most people, who had no reason for distrust, or disquietude, I had taken it for granted, that Mesmer was a madman, or a knave, and his disciples and believers, just of a piece with their master. Observe—I do not say that I *believed* this; but I had become possessed of a sort of notion, that such was the historical fact. About this time, I went to Providence, with a view of satisfying myself about mesmerism, just as I should have gone to Salem, in other days, to satisfy myself about witchcraft—to Providence, Rhode Island, I mean.

There, I entered into the inquiry patiently and carefully, and with a sort of professional anxiety to expose a miserable delusion. But I came away persuaded of the truth. I did not go to scoff—nor did I come away to pray. But I went to satisfy myself respecting what, if true, was likely to open to us new views of the immaterial world. And, I came away, thoroughly convinced, that after allowing what you please for mistake, imposture, sympathy and imagination, there was at the bottom truth enough, and most alarming and important truth, to satisfy any reasonable inquirer, and to make further investigations *a duty*.

I did make further investigations. I tried experiments upon my own family—asleep and awake: in sickness and in health; and upon others: taking care that the subject I operated upon, *should never know what was expected of him*—or of her. Having produced many of the the simpler phenomena—I stopped, afraid of tampering with the brains of healthy subjects, and I was not willing, with my limited knowledge of the science, to proceed further with the diseased, than might be desirable for immediate relief. I had produced a magnetic sleep, more or less profound, in several; cured the severest headaches, pains of the side, &c.. &c., and on one occasion, the only time I ever make the attempt, had succeeded in affecting the stomach and bowels of a child, lying half asleep on the sofa.

I had seen cases of clairvoyance; but, though inexplicable, and accompanied by strange coincidences, they were not satisfactory. I am aware now, that, as it is with all strangers to these manipulations. I had expected too much, something different from what happened. Hence I was disappointed. There was no opportunity for collusion: and there were many failures; but still I saw enough to convince me that there was a sort of spiritual vision—disturbed, to be sure—and very indistinct—like that of a dreamer who sees things half awake—but still a vision, that might be turned to good account, after we should have become familiar with the conditions upon which it is exercised.

That failures occurred; that mortifications happened; failures which the manipulators and lecturers could not themselves account for; mortifications that were likely to throw an air of burlesque over the whole subject, and completely unfit the lecturers for performing, and the public from judging, did not discourage me. For just such things had occurred with Franklin, and with Galvani—with electricity, and with Galvanism. Unaccountable failures happened to both, which neither could explain till the conditions of the atmosphere and the subject, were better understood. It was enough for me, if any *one* experiment was successful—fairly conducted—and incapable of being explained by any known laws, that I happened to be acquainted with—although ten thousand failures preceded or followed it. Meanwhile I continued my investigations.

Briefly, therefore, allow me to state that I entertain no doubt respecting the prodigious augmentation of strength in the patient, at the will of the operator; respecting the clarvoyance of the subject; respecting his power of *perceiving* without the use of his eyes, of tasting and feeling with the organs of another; of the communication by *will* between the operator and the subject, without language, sign or touch; of the reality of the mesmeric sleep; of the power in a sleeper of seeing objects at a distance—perhaps at any distance—nor any doubt respecting any one class of the phenomena supposed to accompany the mesmeric manifestations. All this I believe, just as much as I believe in galvanism, electricity, pneumatics, or the powers of the alphabet; and upon precisely the same evidence, that is upon the evidence of my senses—after long and patient examinations with all the powers of my understanding; after numberless experiments, conducted with the greatest possible care, and under circumstances, where trusting to nobody but myself, there was no opportunity for collusion, and—as I conscientiously believe—none for mistake or imposture.

As I heartily approve the object of Dr. Collyer in establishing his Magazine, I have no sort of objection to the use I understand he desires to make of my testimony in the matter."

Taking it for granted, that Animal Magnetism is real, and no trick or legerdemain, practiced to delude the credulous, what is the real agent that performs these wonders? What forms that chain of communication between the magnetiser, and the magnetised, by which the one can paralyze the muscles of the other, put him into a deep magnetic sleep, or controul his motions, by means of certain manipulations, or, by simple simply looking at him; for there certainly must be a chain of communication of some sort, or there would be no such effects as we witness. We believe that this chain is formed by *electricity*, which is infused by the magnetizer into the system of the magnetized. What else is it—what else can it be? It certainly must be some agent. For never was there an effect without a cause, and electricity is the only agent known to us, whose operations would indicate, that it is capable of producing such surprizing results. But how is it communicated? A solution to this problem can be found by examining the influence which mind exerts over imponderable matter.

What is the communicating agent between mind and the muscles of ones own system, for instance, by which the muscles obey the dictate of the will? Animal electricity doubtless, which, as we have seen, is inhaled with the oxygen, and which resides in the brain and nervous system; for these are nothing but a vast congeries of very fine blood vessels, and this would, therefore, not clash with the proposition, that electricity resides in the blood. When we will to extend an arm. the animal electricity obeys the dictate of mind, and irritates the extending muscles so that they perform the work they were bidden.

Now, by this power, which the mind can exert over the imponderable principle, the magnetizer is enabled, by an energetic and concentrated effort of his will, to send the electricity of his own system into the system of another, and produce by the continued action of the will over the mysterious agent, all the phenomena, which we witness in magnetic somnambulism.

This animal electricity is, therefore. not mind, as some would affirm. It exhibits no governing will of its own, nor does it manifest thought or design in any department of its operations. But is under the control entirely of mind, or will, in obedience with its own organic laws: for, where it is not controled by man, it does the work of Deity and is governed by the will of the GREAT ETERNAL

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NOTE.—Some important matter, which had been promised in the introductory, and in other places, in the forgoing series of lectures, has, owing to certain arrangements, which we need not specify, been omitted *necessarily*, and some of the latter part has been curtailed, more than was designed at the commencement, and during the progress of the work. Among the omissions is that of a vocabulary, the cause of the revolutions of the moon, as reconciled with our theory, a more extended notice of electric Pathology, of Animal Magnetism, and of the Immateriality of mind. Yet, we think that no omissions have been made, which will essentially impair the work. Should a second edition ever be called for, they can be embodied in it.